POWER

Volume 52 New York, September 7, 1920 *Number* 10

Participate in the Activities *of* Your Society

FIFTY years ago the artisan went about his daily task with little regard to what his fellow worker did; the merchant paid scant attention to others in the trade, save to regard them as competitors, and the professional man dealt with his problems as an individual, jealously guarding the knowledge gained by his experience.

While this practice lasted, progress was limited to the capacity of the individual. Today all is changed. We are living in an age of collective effort. Nowhere is this more apparent than in the engineering field, as exemplified by the various engineering associations.

There are two classes of such associations—those that cater largely to the social side, and those whose principal object is to uplift the individual and render a service to society. Benefits from membership in the former are likely to be transient and confined to an extended acquaintanceship. Membership in the latter, however, offers opportunities limited only by the effort which the individual puts into the society.

The initiative in most societies is borne by a comparatively small group while the majority hold aloof, sometimes through indifference, but more often through modesty which restrains the member from offering his services unless called upon. This lack of active participation frequently fosters discontent and sometimes envy of those who rise to positions of distinction in the councils of the society. But let it be remembered that this rise to distinction is seldom through preferment or any unusual qualifications, but rather because the member is always ready to give the best there is in him to the cause.

This is an opportunity that is open to every member if he will attend the meetings, join in the discussions or the presentation of papers, do committee work and mix with the members generally.

The most valuable privilege that membership in the vocational or professional society offers is the opportunity for service. The influence of any society is measured by the activities of its members, and in turn, the greater the influence of the society the greater will be the value of membership in it to the individual.

The New Lakeside Pulverized-Coal Plant, Milwaukee

Largest Power Station in the World Burning Pulverized Coal—Ultimate Capacity To Be 200,000 Kilowatts — Initial Installation of 40,000 Kilowatts Now Going in — Features Are Long, Low, Bungalow Type of Building, Special Coal-Handling and Preparation Equipment, Burners of the Horizontal and Vertical Types and a 500-Kilowatt Turbo-Generator to Supply Current for Station Auxiliaries, Which Will Exhaust to the Feed-Water Heaters and by Thermostatic Regulation Maintain the Temperature of the Feed Water—Machine and Blacksmith Shops Will Be Provided at the Plant

THE Milwaukee Electric Railway and Light Co. has started the construction of what will be the largest central power station in the world utilizing pulverized coal for steam generation. The ultimate installed capacity will be 200,000 kw. The design is such that the plant can be constructed in units. The first will contain equipment sufficient for producing 40,000 kw.; the second and third units, 80,000 kw. each. In conjunction with the present system the plant will supply current for the street railways, street- and house-lighting circuits and power demands of the many industries of Milwaukee and surrounding towns.

With its site one mile south of Milwaukee, directly on the shore of Lake Michigan, the new Lakeside power plant will have an ideal location for several reasons. The water from the lake will be used for condensing purposes and also for boiler feed. Its qualities are such that no purifying treatment will be necessary. Eventually, piers will be built out into the lake at which colliers can be unloaded by a mechanical conveying and storage system that will deliver coal directly through the crushing plant on the shore. For the present coal will be transported by railroad cars and unloaded by means of a car dumper.

First Unit Will Meet Present Needs

Construction now under way embraces the rail connections, cold-storage yards, coal-handling and crushing plants, a breakwater for impounding cooling water and the cooling-water intake and discharge tunnels, each of a capacity sufficient for a total output of 200,000 kw. Present needs will be met when the first unit of the station is completed. As the demand for current increases the other units will be installed, and it will be necessary only to add to the boiler room, turbine room, coal-pulverizing plant and switchhouse equipments, and to the respective buildings for housing them.

In the main building of the plant are the boiler room, turbine room and switchhouse arranged in the order named. The coal-pulverizing plant is in a separate building about fifty feet back of the boiler room. Between these two buildings are two concrete chimneys, each of which serves four boilers. On one side of the main building opposite the turbine room is a connecting building in which will be located the operating engineers' offices, a blacksmith shop, a pipe shop and a machine shop. All these shops will be equipped fully for repairing worn and broken parts of the power-station apparatus. The work will be done by the operating men with the idea of educating them in the construction and care of the machinery they are running. The remaining building is the crusher plant, which is on the shore of the lake about 400 ft. distant from the pulverizing plant. The illustration on the opposite page shows the layout.

Coal Handling a Feature

In this station the coal-handling and preparation equipment differs widely from that of plants using stokers or hand firing. It is best described by following the course of the coal from the storage yards to the boiler furnaces. The coal is received in gondola cars; these are shunted onto a system of parallel tracks between which the coal is piled by three locomotive cranes equipped with 2-yd. clamshell buckets. The coal stored in this manner is for emergency use only. For every-day consumption coal trains are passed through a revolving car dumper, one car at a time, at a maximum rate of about twenty cars per hour. This dumper is located on a bluff running along the lake, and coal passes by gravity through the crushing-plant machinery in the following order: After being fed from the hoppers under the dumper, it is carried by a 48-in. belt conveyor to a rotary grizzly. The head pulley of the conveyor is highly magnetized and carries tramp iron to its under side, thus separating it from the coal. The grizzly screens out coal 2 in. and over and discharges it into a two-roll crusher which reduces it to 2 in. and under. The crushed coal, together with that passed through the grizzly, is fed through a hammer mill, which reduces it to ½ in. in size, and onto a 36-in. belt conveyor which leads to the pulverizing plant.

The crusher plant, when operating as described, will handle 150 tons per hour. When fine coal is received it is bypassed directly to the belt conveyor under the hammer mill, and 250 tons per hour can be handled. The crusher building is designed to accommodate two grizzlies, crushers and hammer mills, and when these are installed it will be necessary only to double the speed of the conveyor to double the capacity of the layout as a whole.

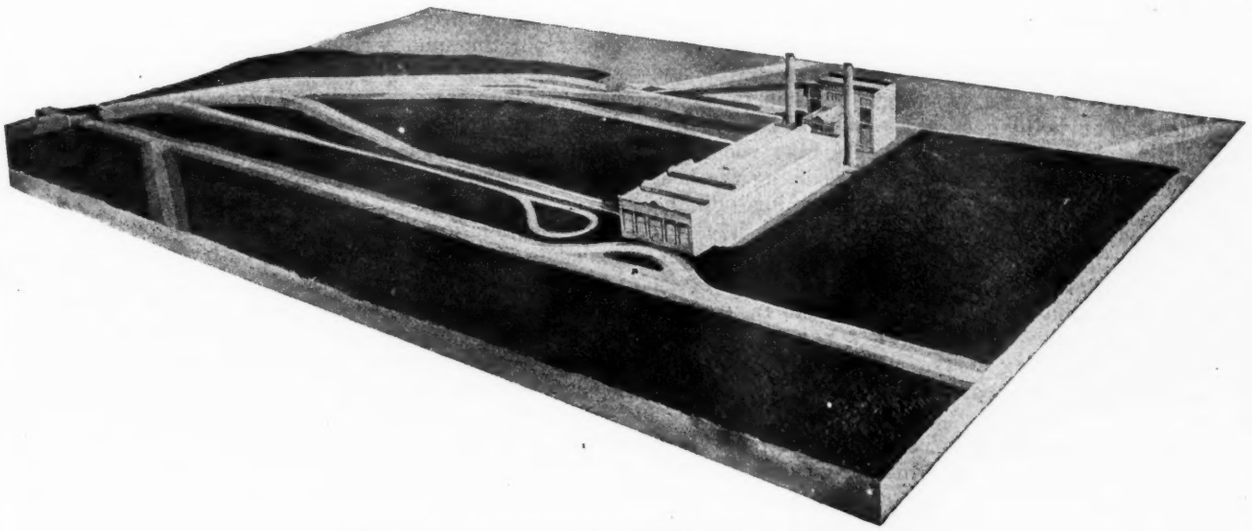
The belt conveyor leading to the pulverizing building is 36 in. wide and in its length of 385 ft. rises 91 ft. It discharges onto a reversible cross-belt con-

veyor of the same width, which distributes the crushed coal to three parallel conveyors equipped with automatic trippers which pass over the green-coal storage bins in the pulverizing building and maintain an even supply in them. There are seven of these bins, having a combined capacity of 3,500 tons. Under the bins run three 12-in. screw conveyors arranged to discharge through automatic scales into three indirect-fired rotary driers 5 ft. 6 in. in diameter and 42 ft. long. These driers reduce the moisture in the coal to about 1 per cent by means of hot gases from individual furnaces fired with pulverized coal. After being exhausted from the drier, the gas is blown through collectors 14 ft. in diameter, which recover any coal dust it carries away in passing through the agitated coal. The hot, dried coal is next transported to the mill feed bins by means of parallel arrangements of 16-in. screw conveyors and continuous-bucket elevators, each set having a capacity of 60 tons per hour, which is also the combined capacity of the three driers. The idea is to provide spare capacity in case of breakdown.

There are eight mill feed bins, each holding 25 tons and placed over its respective mill. Fuller-Lehigh ball pulverizing mills utilizing the air separation system will be used, and they will have a total hourly capacity of 48 tons. With the air-separation method no screens are needed; an exhauster driven by the mill shaft draws a current of air over the bull ring in the mill, and the velocity of this air is such that it picks up only those particles that have been ground to the necessary fineness. The dust thus formed is forced through a collector which separates the coal, and the air is conducted back to the mill to be drawn through again, thus making a continuous circuit. From the collectors the pulverized coal is conveyed to a 50-ton storage bin supplying a pneumatic conveying system which transports it to four sets of bins over the firing aisle in the boiler room. One set of bins will hold 150 tons of coal.

Six of the boiler furnaces will each be fired by three duplex burners (Combustion Engineering Co. type) set vertically through the top of a dutch oven. About 15 per cent of the necessary air is blown in with the coal dust, and the rest is admitted through a number of openings in the front wall of the furnace. These openings are fitted with top-hung doors used for regulating the air supply. The remaining two boiler furnaces each have four Fuller burner nozzles. These are of the horizontal type and are placed in the front furnace wall. Air for combustion is admitted partly with the fuel and partly induced through an annular space around the nozzle. The idea of installing two different schemes for burning is to compare them under actual operating conditions, with the view to adopt the better type in case of future additions that may be made to the station.

When operating either of these burning systems the flame temperature never will be allowed to rise high enough to slag the ash content of the coal, hence this will be deposited partly on the hearth and partly carried away with the flue gases in the form of dust. What amount collects in the furnace will be removed through cleanout doors in the boiler-room basement and fed by hand into the pipe line of a vacuum conveying system, which will carry it to a conveniently located ash hopper.



MODEL OF LAKESIDE POWER PLANT AND GROUNDS

In the station the main power equipment will be two 20,000-kw. turbo-generators, each equipped with a 35,000-sq.ft. three-pass surface condenser. Steam at 265 lb. pressure and 200 deg. F. superheat will be supplied from eight water-tube boilers, each rated at 1,306 hp., but to be operated at 250 per cent of rating. An economizer having 7,503 sq.ft. of heating surface will be installed in the rear of each boiler and also an individual exhaust fan for assisting the natural draft in drawing the gases through it. Dust removed from the economizer tubes will fall into hoppers from which it will be carried away by connections to the vacuum ash system.

In a gallery between the boiler and turbine rooms the principal auxiliaries will be located. An elevated hotwell tank will supply feed water to two Hoppes open heaters, from which the water will flow through a V-notch meter on the floor below. Under the meter will be placed four boiler-feed pumps, two motor-driven and two turbine-driven. It is estimated that the feed-water temperature leaving the pumps will be 120 deg. F. and under a pressure of 325 lb. gage. In addition there will

be one 500-g.p.m. centrifugal motor-driven makeup pump and two 500-g.p.m. motor-driven centrifugal house-service pumps.

A unique feature of the plant will be a 500-kw. turbo-generator which will supply current at 480 volts for station use. The turbine end of this machine will be equipped with a diaphragm operated governor controlled by a thermostatic device located in the feed-water heaters. The purpose of such an arrangement is to regulate the temperatures of the feed water by varying the amount of the exhaust steam passing into the heaters from this turbine. The electrical load on the generator side will be balanced with a transformer connected to the main station busses. With the aid of this unit the main turbo-generators can be started under a vacuum in cases of complete isolation from an outside source of power, as the electrical auxiliaries of the condenser can be operated with current supplied from it.

The main condenser auxiliaries will comprise a motor-driven centrifugal condensate pump discharging through a heater to the elevated hotwell tank, two 24-in., 18,000-g.p.m. circulating water pumps, one motor-driven and one turbine-driven, and a steam-jet air pump for emergency use. The main generators will be cooled with washed air taken from inside the turbine room and discharged into the boiler room, thus utilizing the heat lost in one department to warm the air going into the boiler furnaces.

As a whole the plant will be modern in every respect. The best materials will be used throughout, and every precaution has been taken in the design to insure efficient and easy operation. At every point necessary, recording or indicating instruments will be installed so that each piece of apparatus will be run at its best efficiency.

The design is the conception of John Anderson, chief engineer of power plants for the Milwaukee Electric Railway and Light Co., who has already demonstrated the many advantages of pulverized fuel in the Oneida Street Plant, which has been operating successfully for the last three years. The plans were prepared and the construction work will be carried on by the engineering staff of the company.

New Type of Transformer Bushing and Housing

A new type of bushing and housing for outdoor transformers of moderate voltage has been developed. This bushing, which has been approved by the Inspection Department of the Associated Factory of Mutual Fire Insurance Companies, should make it possible to dispense with transformer houses. Transformer houses are specified, in some localities, by insurance companies, their construction being determined by the requirements of insurance companies and safety-first considerations.

General Arrangement of Connections

The scheme provides that all circuits, as shown in Fig. 1, generally above 600 volts, be brought to the housing in inclosed cables. This cable is above ground, in a metal duct that is securely fastened to the transformer cover, all exposed parts being at ground potential and waterproof. The waterproof feature is essential, from the underwriter's standpoint, in making it safe for firemen to play streams on burning buildings near the transformers. Since the circuits to the transformer will generally consist of waterproof lead-covered cable, provision is made in the outboard portion of the housing for inclosing a standard end bell, corresponding to the circuit voltage.

The installation shown in Fig. 1 is that of three self-cooled oil-insulated transformers, with corrugated tanks and radiators for cooling the oil, located outside of an industrial building. The general method employed in bringing the conduits and conductors into the transformer, so as to make a clean and neat installation, is clearly indicated.

The lower portion of the bushings are similar to the standard General Electric Co.'s high-voltage bushing; the upper portion is shown in Fig. 2. Ample clearance is provided in the housing. The transformers receive standard high-potential test with housings in position and without any taping or other insulation on the bushings. As regards voltage the use of these transformers is limited only by the voltage limits of the underground cable.

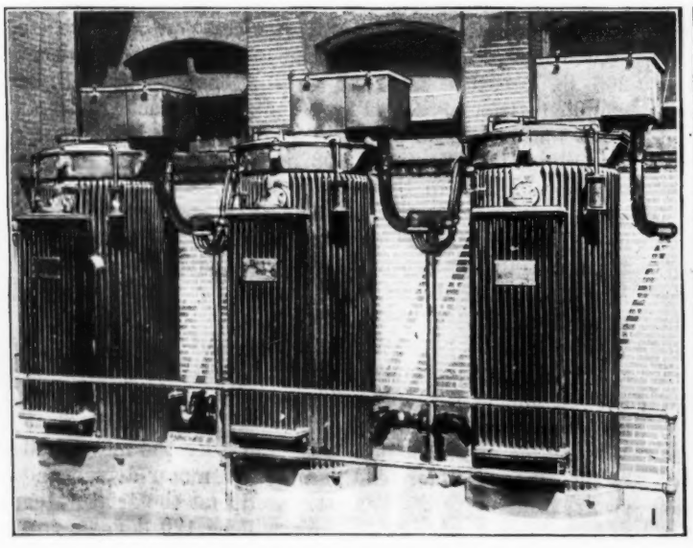


FIG. 1. OUTDOOR TRANSFORMER INSTALLATION

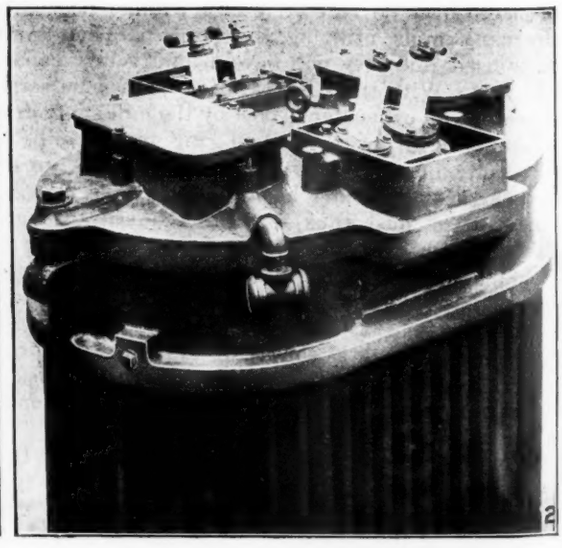


FIG. 2. BUSHINGS IN TOP OF TRANSFORMER

Measuring River Flow for Hydro-Electric Plant Operation

Problem of Calculating River Flow—River Flow Charts Used in the Operation of One Installation—Methods of Checking Capacity of Ponds—In Calculating Capacity of Pond, Hydraulic Gradient Must Be Considered

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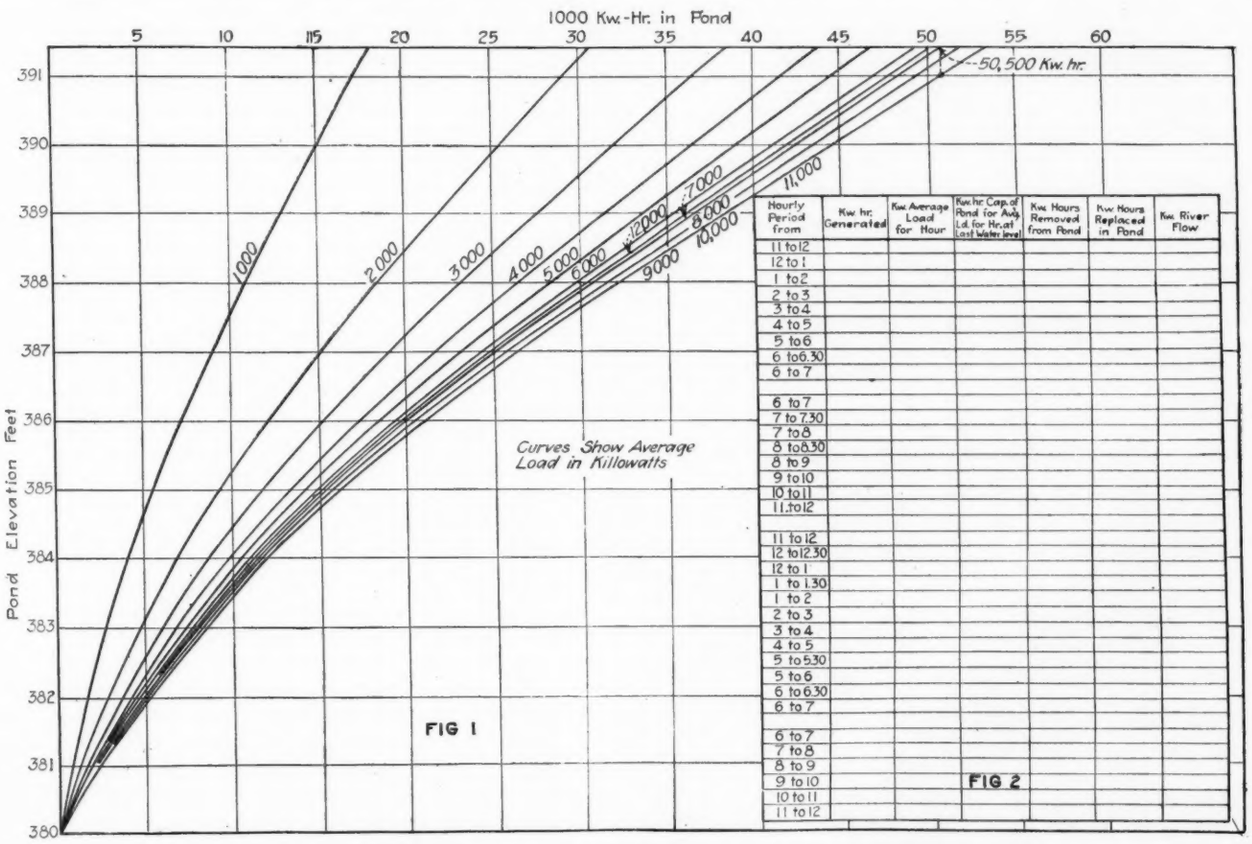
IN the combined operation of steam-driven and hydraulically driven generating plants very substantial economies can be effected by the proper distribution of load between two generating stations or between several steam and hydraulic stations, especially in cases where the river flow for the hydraulic stations is variable. The problem of measuring this river flow in some easy, practical manner, so as to give the load dispatchers a fairly accurate basis to divide their load on, is fundamental.



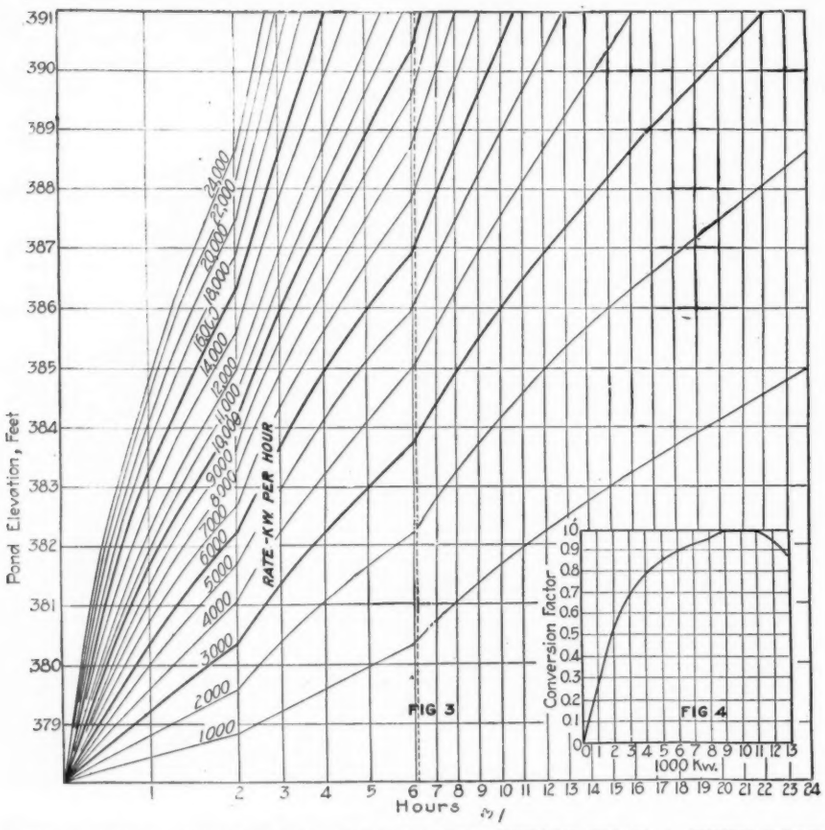
FIGS. 1 AND 2. CHARTS FOR ESTIMATING POND CAPACITY AND RIVER FLOW

The most accurate method, of course, would be through the installation of a weir in the river by means of which the actual quantity of water flowing could be measured. This is not only expensive, however, but in many cases practically out of the question, and consequently some other method has to be devised.

In almost every case any hydro-electric generating plant has some storage capacity above the dam, and the pondage is used to a greater or less extent, depending upon whether the river flow is sufficient to provide all the power required all the time or not. If the river flow is not sufficient to supply the maximum amount of power required, then during the peak-load period on the plant the waterwheels will be using the total river flow and in addition will be drawing a certain amount of water from the pond. During the summer of 1919 the writer devised for use on the power system of the Rochester Gas and Electric Corp., Rochester, N. Y., a method of measuring the river flow, making use of the foregoing characteristic.

A determination was first made of the capacity of the pond in cubic feet so that the volume of water contained in the pond for any elevation was known. Knowing the amount of water contained in the pond, the head on the wheels, and the turbine and generator efficiency for a given load, it is evident that the number of kilowatt-hours that can be generated at that load if all the water in the pond were passed through the wheels can be calculated. Assuming that the hydro-electric plant would be supplied only with water from the pond and that no

additional water was entering, the curves shown in Fig. 1 were plotted. In these curves, instead of using cubic-feet pond capacity, the capacity is expressed in thousands of kilowatt-hours. At an elevation of 391 ft., for instance, the capacity of the pond when the water is used at maximum efficiency is 50,500 kw.-hr. In the case of the two 12,000-kw. generators used for the particular installation for which these curves were calculated, the maximum efficiency is at 10,000 kw. with very little change in efficiency for any load between 9,000 and 11,000 kw. on the unit. If the load on the unit is above or below this amount, the efficiency at which the water is used is decreased; consequently, when a given amount of water is passed through the wheels, a smaller number of kilowatt-hours will be generated, due to the decreased efficiency in the use of the water. Therefore curves for other loads than the 9,000- to 11,000-kw. loads were calculated and plotted on the chart. For example, with a load of 5,000 kw., the kilowatt-hours in the pond at an elevation of 391 ft. amount to only 44,500, a loss of 6,000 kw.-hr. due to the decreased efficiency at which the wheels are operated.



FIGS. 3 AND 4. CHARTS FOR CALCULATING PERIOD THAT A GIVEN LOAD CAN BE CARRIED WITH POND AT A GIVEN LEVEL

The load dispatchers are provided with a form for entering the necessary data to calculate the river flow as shown in Fig. 2. This shows for each hour: The total kilowatt-hours generated for the hour, average load for one machine for the hour, the kw.-hr. capacity of the pond for the average load at the end of the hour, the kw.-hr. removed from the pond, the kw.-hr. replaced in the pond and the kw. river flow.

To illustrate the use of the method, let us assume the following data:

At 9 a.m. the pond elevation is 391 ft. and at 10 a.m. the elevation is 390 ft. and the total generation by two generators for the hour has been 20,000 kilowatt-hours, equivalent to an average load of 10,000 kw. on each generator.

Referring to the chart we get the following information:

Pond capacity at 9 a.m., at a load of 10,000 kw	50,500 Kw.-hr.
Pond capacity at 10 a.m., at a load of 10,000 kw	44,500 "
Kilowatt-hours removed from the pond during the hour	6,000 "
Total kw.-hr. generated during the hour	20,000 "
Less kw.-hr. removed from pond	6,000 "
Difference equals river flow	14,000 "

By making this calculation every hour continuous check can be kept on the river flow.

In the left-hand column of Fig. 2, the half-hour periods are put in during the time when the system load is changing rapidly. During this period half-hour readings are taken, but the kilowatt river flow estimated from these readings is not used except as a very rough check on the river conditions. We have found from experience that, with the conditions existing in the pond, half-hour period readings do not seem to be long enough to iron out various inconsistencies and give reliable data. We have therefore made it a practice in estimating the kilowatt river flow to use only hourly periods. The hourly tabulation is arranged in the various vertical groups so as to give space for totalizing each group and figuring average results for each group. Our load conditions are such that we have found it convenient to divide the day into four periods—from midnight to 7 a.m.; 7 a.m. to noon; noon to 7 p.m., and 7 p.m. to midnight. For convenience the readings from 11 p.m. to midnight, from 6 a.m. to 7 a.m., from 11 a.m. to noon, and from 6 p.m. to 7 p.m. are repeated. These repetitions are not necessary, but our operators have found it convenient to handle it in this way. In figuring the river flow for each group this overlapping of one hour gives a more reliable average figure. The various vertical groups contain a different number of units, depending upon how many half-hour periods happen to fall in a given group.

One factor entering into this, which tends to make the results more or less deceptive, is the effect of the hydraulic gradient of the pond itself, in those cases where the point at which the pond level is measured is at the dam or at the intake. If we start out with the surface of the pond absolutely level from the intake back upstream to the upper limits of the pond and then use water at a rate greater than that at which it is flowing into the pond, it is evident that the level at the intake will fall a larger amount than the level farther up the pond, owing to the hydraulic gradient, or difference in head required to make the water run downstream. The more rapid the rate at which the pond level is falling, the greater will be the difference in the pond elevation at the intake and at the upstream end, especially in those cases where the pond is shallow and uncov-

ers considerable ground area as the level falls. As the elevation at the intake is the lowest in the pond, it is lower than the true average level for the entire pond. The figure for the number of kilowatt-hours taken out of the pond will therefore be greater than is actually the case, if it is based upon the elevation of the lowest point rather than the average elevation. The effect of this is to give a river flow lower than the true flow. This error, however, is not one that need cause the operators to worry for fear the water will give out before they expect it to, as it is on the safe side and means there is actually somewhat more water available than the figures indicate. In those cases where the pond elevation can be measured at a point that gives a figure that is more nearly the average pond elevation, this error will be practically eliminated.

In constructing the curves shown in Fig. 1, it is not absolutely essential to have a survey of the pond, as these curves can be constructed by a series of approximations from the operating data only. Assuming that only very rough information is available in regard to the pond capacity, a set of curves could be plotted based upon this rough estimate. In the course of operation there will be periods when the amount of power being generated by the plant will be only a relatively small amount greater than the river flow, so that the rate of fall of the pond will be slow, thus minimizing the effect of hydraulic gradient. These operating results will give certain river-flow figures. Taking the average of these figures over a period of, say, three hours, a determination can then be made along the general lines indicated in the following calculation:

Average flow, in kw., for a period of three hours	15,000
Pond capacity, in kw.-hr., from given curves at end of this time	50,000
Kilowatt-hours generated during next period of five hours	100,000
Capacity, in kw.-hr., from given curves, at end of the five hour period	20,000
Kw.-hr. generated by river flow of 15,000 kw. for five hours	75,000
Kw.-hr. actually supplied by pond	25,000
Kw.-hr. apparently supplied by pond as shown by curve	30,000
Error in pond capacity in kw.-hr	5,000

By choosing a period during which it is fairly certain that the river flow is constant over the assumed period of five hours, as given, this method can be used to determine the inaccuracy in the assumed chart, and after such determination a corrected chart can be made. This corrected chart can be again checked in the same way and a third chart made which will be more nearly correct than the second.

The results secured by the foregoing method can be checked by still another scheme. During periods of operation when the pond is drawn down low during the heavy-load period of the day and allowed to fill up during the light-load period, if we start at a time when the pond is full and take hourly readings during the period when the pond is being emptied and filled, it is evident that at the end of the filling period the river flow will have been sufficient to generate the total kilowatt-hours generated from the start. The average river flow will then be the total kilowatt-hours generated, divided by the total time. For any hour a comparison can be made between the kilowatt-hours removed from the pond as determined by subtracting the average river flow from the total kilowatt-hours actually generated for that hour, and the kilowatt-hours removed from the pond as determined from the chart by the method outlined in the foregoing.

Even in cases where an accurate survey of the pond is available, the methods outlined can be used to check the pond from time to time to determine the amount that it has silted up.

In order to assist the load dispatcher in estimating the number of hours that he will be able to carry a given load with a pond at any given level, the chart shown in Fig. 3 was drawn up. The curves on this chart represent the rate at which the pondage is being depleted. For example, if the pond elevation was 387 ft. and the load carried by the station such that 6,000 kw.-hr. were being taken out of the pond every hour, these curves show that this load could be carried for about six hours, at the end of which time the pondage would be all used up. These curves are based upon an assumed operation of the wheels at their highest point of efficiency. In case the wheels are not operated at this point but at a less economical load, use is made of the conversion factors shown in Fig. 4. In the case cited, for instance, if the load being carried by each machine was only 7,000-kw., then the length of time that the pondage would last would be only 93 per cent of six hours, or 5 hours and 34 minutes.

The load dispatcher can also make use of an estimating sheet on which he can put down the estimated load, river elevation, etc., for each hour for an entire day's operation, checking up the results actually gotten at the end of each hour and changing his estimate if conditions are such as to make this advisable. With an estimating sheet of this kind he can cover any period and any variation in load.

This system has been in use for a number of months, and on the whole the results have been found very satisfactory. Irregularities in the pond capacity have been found and corrections made from time to time to overcome these errors. A great deal has been learned about hydraulic gradient and its effect on the load conditions, and from experience the dispatcher makes allowance for the effect of this factor.

A Large Semi-Diesel Engine

Certain industries, especially rice irrigation and cotton ginning, have fairly large power requirements for a few months each year. During the remainder of the year the power plant is idle. Even though the fuel economy of the Diesel engine is much better than that of any other prime mover the interest charge per operating day is large in such plants. The surface-ignition or semi-Diesel oil engine, while using more oil per horsepower, is frequently the most advisable type to install, since the interest charge is lower; in addition, the surface-ignition engine operator need not be as high-grade as the Diesel engineer.

Heretofore most of the semi-Diesel manufacturers have confined the engine cylinders to a maximum of about 17 inches. It has been quite generally felt by the designer that this diameter was the largest that could be employed in a two-cycle engine without recourse to some form of piston cooling. Piston cooling, while customary with two-cycle Diesels, has not in the past met with favor in the semi-Diesel field. It is undoubtedly true that a so-called dry type semi-Diesel or surface-ignition oil engine would require piston cooling if manufactured in large cylinder sizes. With the wet type engine, or an engine using water injection into the working cylinder, it is claimed by several builders that the water thus introduced keeps the temperature of the piston head low enough to avoid danger of fracture or cylinder scoring regardless of the diameter of the cylinder.

With the experience of many years of oil engine construction to guide them the Power Manufacturing Co. of Marion, Ohio, has for some time been building the Primm surface-ignition engine in single-cylinder units with a cylinder diameter of 22 inches. This single-cylinder unit develops 150 hp. at 200 r.p.m.

To meet the demand for a 250- to 300-hp. engine for gin and irrigation plants, this company has designed a two-cylinder engine having cylinders 22 inches in diameter by 24 inch stroke. Fig. 1 is a view of the pump side of the engine, while Fig. 2 is a cross-section showing the moving parts. The frame is a one-piece casting containing housing for three shaft bearings. At the head end the frame has two cavities to receive the cylinders. It will be seen that the front or crank ends of the cylinders act as the compressors for the scavenging air. The air is admitted through a poppet valve mounted on the side of the frame. As the piston uncovers the exhaust pipe, the scavenging air rushes into the cylinder through the upper ports and completes the scavenging process.

Injection Water Under Control

The injection water is fed into the air transfer ports and is picked up by the air entering the cylinder. The velocity of the air serves to break up the water into a fine mist. This water vapor passes across the piston head and removes a great amount of the heat absorbed during the early part of the power stroke. The amount of water injection is controlled by the governor, while a special form of check valve prevents the entrance of the water into the air passage save during the period of exhaust and air scavenging. This timed injection of water removes a great deal of the objection that is so frequently raised by engineers to the wet type of engine. Doubtless if the water is allowed to drip onto the piston the lubricating oil will be washed off. Regulation of the timing places the water in the cylinder at the proper time to be most effective.

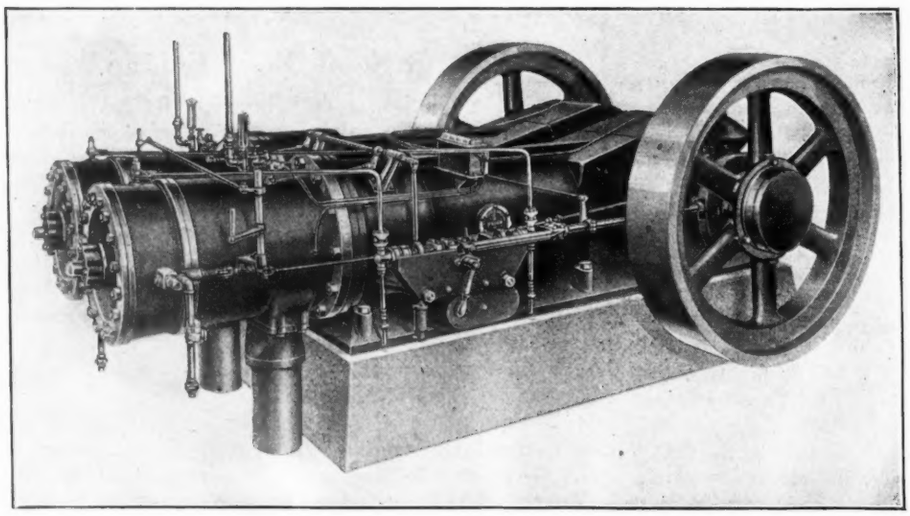


FIG. 1. PRIMM SEMI-DIESEL ENGINE

The governor is of the centrifugal flyball type and is driven by a bevel gear mounted on the crankshaft. The governor sleeve is connected to a rocker arm on the fuel pump, as appears in Fig. 3. This rocker has a dog which fits into a notch cut into the fuel pump plunger. The plunger is driven by a push rod from the shaft eccentric. The dog limits the travel of the pump plunger on its suction stroke. At an increase of speed the governor

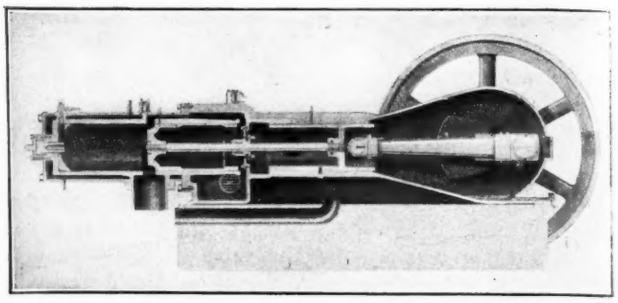


FIG. 2. CROSS-SECTION OF PRIMM OIL ENGINE

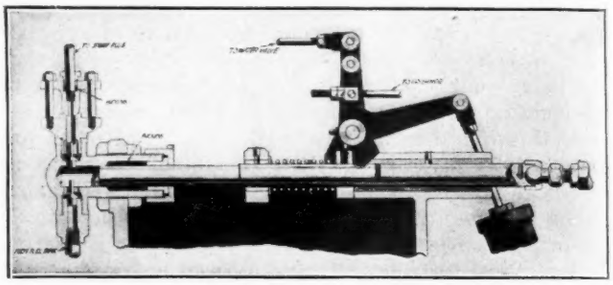


FIG. 3. FUEL PUMP OF PRIMM ENGINE

shifts the pump rocker. The dog then engages the pump plunger earlier in the suction stroke and the amount of fuel entering the pump is thereby reduced. On the twin cylinder engines, the pump is double acting, allowing the use of a single eccentric and push rod.

The atomizer or spray nozzle is the Primm standard design and enters the cylinder at the top. The oil, as it enters the cylinder, strikes the hot plug in the cylinder head. The fuel injection timing varies with the load. At full load the beginning of injection is about 20 deg. ahead of dead center and the injection ceases at dead center. The ignition plug follows the usual Primm design. It is heated by a torch and then slipped into the cylinder head and locked by means of a screwed cap.

The engine is not devoid of striking features. It is much simpler than a Diesel engine and can be operated by any average mechanic. In many engines the frame becomes rather warm from the heat absorbed by the cylinder and piston. In this engine the cooling water enters the frame in front of the main bearings. Cored passages allow the water to pass toward the cylinders, in this way keeping the engine frame at all times much cooler than is customary with the usual design of two-cycle semi-Diesels.

Connections Between Brushes and Brush-Holders

Tendency Is Toward the Use of Flexible Connections Between Brushes and Brush Holders—Voltage Drop Between Brush and Holder May Represent an Appreciable Loss—Load Current Passing from Brush to Holder Causes Serious Injury to Both—Three Methods of Connecting Shunts to Brushes and Their Relative Merits

By WARREN C. KALB
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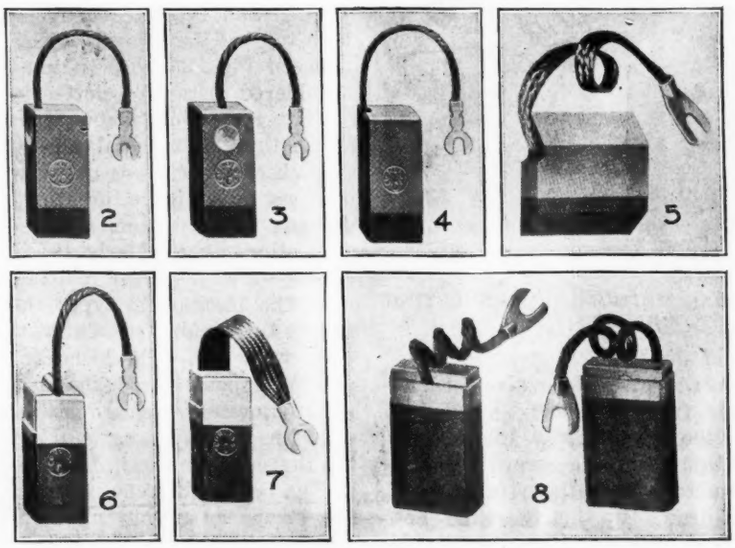
DURING the last few years there has been a rapidly growing tendency on the part of manufacturers of electrical machinery toward the use of flexible connections between brushes and brush-holders or some portion of the brush-supporting rigging. These flexible connections are usually termed shunts or pigtails. Some of the reasons making the use of such a connection desirable are the elimination of the voltage drop between brushes and brush-holders, the prevention of the passage of load current through the tension spring of the brush-holder, the reduction of side burning and the insuring of equal distribution of current among all the brushes. Referring to the first reason given, the voltage drop between brush and brush-holder may not seriously impair the efficiency of a high-voltage machine, but on a machine of relatively low voltage the percentage of loss due to poor contact between the brush and brush-holder may represent an appreciable loss of efficiency. This drop may be as much as two or three volts or even more should the brush become coated with grease or oil. On a 32-volt machine such as used for farm lighting, it will be seen that this will represent 6 to 10 per cent loss in efficiency, which would be a prohibitive figure when it is so easily overcome by establishing a low-resistance flexible connection between the brush and brush-holder. This condition applies principally to box-type holders in which the brush has a free movement within the holder guides. The use of a shunt is not so important on clamp-type holders where much better contact is secured between the holder and the brush. This contact, however, is not as low in resistance as can be obtained by the use of a properly connected shunt, and for this reason shunts are used to a considerable extent even on holders of the clamp type.

FIG. 1. EFFECTS OF OPERATING BRUSH WITHOUT A SHUNT

The most serious difficulty arising from the passage of load current through the tension spring of the brush-holder is the heating that will result, with the possibility of destroying the temper of the spring. Where this takes place, unequal tension on the brush is a certain result, leading to such troubles as excessive vibration, sparking and overheating of the brushes on which heavy tension remains.

In addition to considerable current passing through the tension spring when no shunt is used, a large amount will go directly from the brush to the sides of the brush-holder. This will not be evenly distributed over all the available bearing surface, but will be localized in a few points of contact at which the current density will be quite high. The play of the brush in the holder causes frequent interruption of the current at these points of contact, resulting in the drawing of small arcs, which rapidly burn away both the brush and the interior surfaces of the holder. Fig. 1 shows a brush operated without a shunt, and how serious this side burning may become under severe load conditions. The use of a flexible connection between the brush and holder will almost entirely eliminate such action, even under very severe conditions.



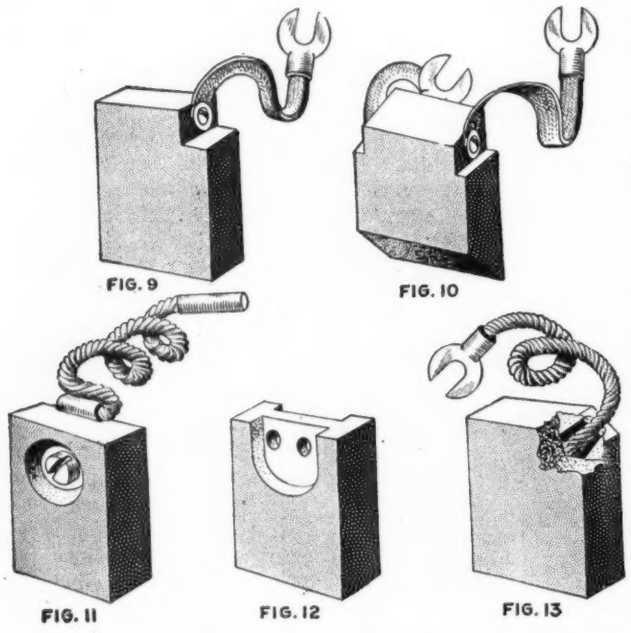
FIGS. 2 TO 8. METHODS OF SOLDERING SHUNTS TO BRUSHES

Equal distribution of load current among all the brushes cannot be too greatly emphasized and constitutes one of the most important reasons for the use of flexible connections. Unequal distribution of current not only causes serious injury to the brush which

is carrying an excessive share, but through the glowing and sparking so produced may cause serious injury to the commutator, necessitating expensive repairs. Even where shunts are used, unequal distribution will sometimes exist if they are not properly connected to the brush or if the connection to the brush-holder is poor, whether due to dirty contact or to a loose screw. Troubles due to unequal distribution on machines where the brushes are equipped with shunts may often be eliminated by cleaning and tightening the contacts of all the pigtail terminals.

The method of connecting the flexible cable of the shunt or pigtail to the brush is of the greatest importance. In the first place, the connection should be of low electrical resistance. As an aid to this characteristic, it should have as large an area of contact as possible and the contact should be firm at all points. The use of solder is of considerable advantage in securing low resistance, but care should be taken in the construction of the connection so that there are no pockets where an excess of solder can gather to drop out on the commutator or cause the brush to stick in the holder should a temperature be encountered during operation sufficient to cause the solder to melt.

A second feature of importance is the mechanical security of the connection. Many connections are used successfully which depend entirely on solder to secure the cable to the brush. Such connections are subject to failure, however, when high temperatures are reached, and a connection that is secured mechanically independent of the use of solder possesses an appreciable



FIGS. 9 TO 13. MECHANICAL METHODS OF CONNECTING SHUNTS TO BRUSHES

advantage over the former type. Mechanical connections should also be free from a tendency to loosen under vibration or from the expansion of the metallic parts when heated. In this respect a screw-type connection possesses an advantage over the riveted type, inasmuch as it can be drawn up firmly while hot, whereas the riveted type is always attached to a cold brush. The metal is subject to greater expansion than the carbon when the brush becomes heated in service. All connections should be able to withstand a moderate pulling strain without breaking away from the brush, but excessive strain of this nature will not be encountered in service, so that the fact that a cable can be pulled from the brush by hand is not in itself sufficient reason for condemning a connection.

A third point to be considered in the method of connecting the cable to the brush is simplicity. This applies particularly to the machining operations required upon the carbon itself. Carbon cannot be machined efficiently with steel tools, inasmuch as it rapidly dulls the cutting edge of a tool of this character. All operations should be done with grinding wheels where they can possibly be applied. Of course, in drilling, counterboring and similar operations the use of a steel tool is necessary.

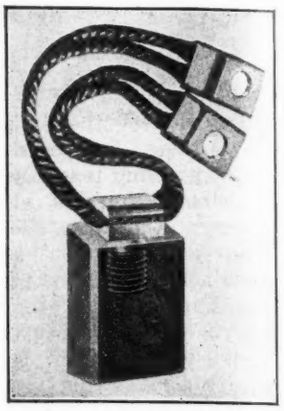


FIG. 14. LOW-RESISTANCE BRUSH WITH SHUNT

Methods of connecting the shunt to the brush may be grouped in three classes—soldered connections, mechanical connections and the combination of these two. Figs. 2 and 3 illustrate the simplest form of the soldered connection, consisting of a hole drilled into the top of the brush through which the cable is inserted, spread out in a counterbore drilled in the edge or side of the brush and there soldered. In this, as in all soldered connections, it is necessary that the brush be copper plated.

Fig. 4 is a modification of Figs. 2 and 3, in that the cable is inserted in a hole drilled through the width of the brush, countersunk at one end for soldering and slotted at the other end to give clearance to the shunt and avoid interference with the side of the brush-holder box. This connection is somewhat better than that in Figs. 2 and 3, inasmuch as the solder will draw back along the cable and give a larger area of contact between cable and brush. Fig. 5 is a modification of the type Fig. 4, and is quite commonly used on brushes with both top and face bevels. The only essential difference between Figs. 4 and 5 is that the edge of the brush is shouldered instead of slotted in the latter case.

Figs. 6, 7 and 8 show strictly soldered connections. While there is a metal cap over the top of the brush in each of these types under which the cable is spread out, giving a large area of contact, the connection depends entirely upon solder for its security. These connections, particularly those in Figs. 6 and 7, are of very low electrical resistance.

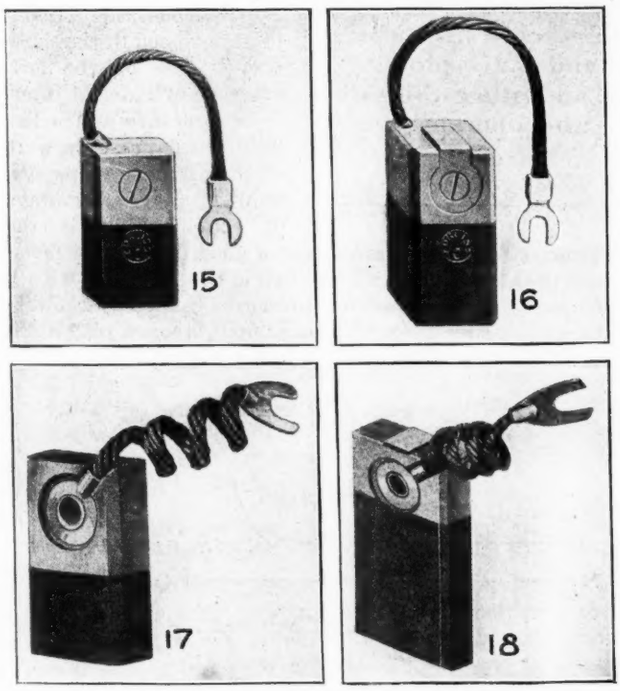
Of the mechanical types there are numerous forms in which the cable is secured to the brush by means of a screw or nut. The brush in this case may be either plain or copper coated, the latter form usually being of slightly lower electrical resistance than the former. Another mechanical type in use to a considerable extent has the same appearance as the soldered type illustrated in Fig. 5, the difference being that the flat cable, which may be opened up into tubular form, is pressed into firm contact with the interior of the brush and there secured by a pin of the proper size, driven in from the oppo-

site edge to that visible in the illustration. A modification of this type is shown in Figs. 9 and 10, in which the cable is secured by a tubular rivet passing through the width of the brush and spun over on the end. A detachable type, Fig. 11 is extensively used by one manufacturer, but is subject to the fault that a portion of the connection extends beyond the side of the brush, necessitating a deep slot in the brush-holder.

Fig. 12 shows the preparation of a brush for what is known as the saddle-type connection. This connection consists of a heavy sheet-copper clip or saddle fitting into the recesses of the brush shown in the figure and secured thereto by bolts and nuts. Flexible cable is attached directly to this saddle. This type is quite expensive from the standpoint of the preparation of the brush as well as the cost of the saddle, and as a result it is rapidly passing out of use.

For metal-graphite composition brushes in which the percentage of metal is very high, the connection in Fig. 14 is often used. In some cases, particularly on small metal-composition brushes, the cable is often secured to the brush merely by inserting a pin or screw alongside of the cable or through it after it has been inserted into a snug-fitting hole in the brush.

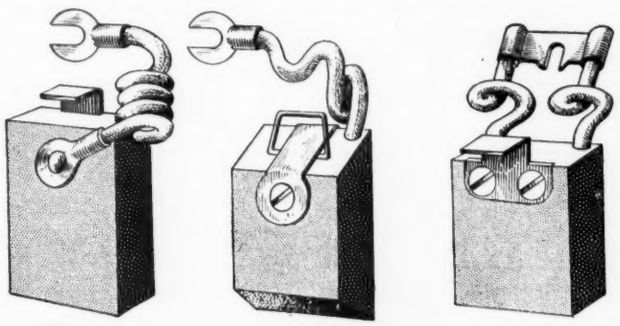
One other type, Fig. 13, quite extensively used, comes under the classification of mechanical connections. In this type a single hole is drilled into the brush, usually through the top or from a beveled upper corner. The diameter of the hole is larger than that required to accommodate the cable, and the hole is sometimes



FIGS. 15 TO 18. COMBINATION TYPES OF CONNECTIONS

slightly undercut or enlarged at the bottom. After inserting the cable into the brush, copper powder specially prepared for this purpose, or a conducting cement having the characteristic of hardening after a short period, is tamped in alongside the cable, establishing firm contact and mechanical security between the cable and the brush. This connection has a pronounced advantage from the standpoint of simplicity, but is lacking in mechanical security. It also has a comparatively small area of contact, and while the electrical resistance may be low, there are failures when heavy currents are carried by an individual brush.

Of the combination types, Figs. 15, 16, 17 and 18 illustrate the two forms most commonly used, Figs. 15 and 16 being a screw-type connection and Figs. 17 and 18 a modification in which the cable is secured by a hollow rivet inserted through the thickness of the



FIGS. 19 TO 21. BRUSHES EQUIPPED WITH LIFTING CLIPS

brush and spun over on the ends. These types, as will be noticed from the figures, can be made with or without a metal clip extending over the top of the brush to prevent wear under the tension spring of the brush-holder. Other modifications of this type are illustrated in Figs. 19, 20 and 21, which show various forms of lifting clips attached to the top of the brush. These are used on interpole rotary converters, started from the alternating current side, to lift the load carrying brushes out of contact with the commutator during the starting period. All the combination types here illustrated may be attached to copper-coated brushes without the use of solder, but the electrical conductivity is so greatly improved by the use of solder that this has become the almost universal practice.

Two forms of copper cable are used for pigtail connections, the braided form illustrated in Fig. 7 and the stranded form, Fig. 6. Braided cable is of advantage where flat contact surface is desirable, as in the connection, Fig. 7, or where a rivet or pin is to be inserted in the cable, as in Figs. 9 and 10. Braided cable, however, is not as flexible as stranded cable, and for this

CARRYING CAPACITIES OF VARIOUS STANDARD SIZES OF STRANDED CABLES

Number of Wires	B. & S. Gage No.	Circular Mils	Approximate Diameter of Cable Inches	Carrying Capacity Amperes
105	40	1,038	1/32	8
63	36	1,575	3/64	10
105	36	2,625	1/16	13
161	36	4,025	5/64	19
238	36	5,950	3/32	25
392	36	9,800	1/8	37
525	36	13,125	9/64	48
644	36	16,100	5/32	58
833	36	20,800	11/64	73
1,050	36	26,250	3/16	90

reason the latter is preferable in most instances. Wire of No. 36 B. & S. gage is fine enough to give the necessary degree of flexibility in all but the smallest cable, in which case wire as fine as No. 40 B. & S. gage may be used. In the table is given a list of carrying capacities for various standard sizes of stranded cable. These figures have been determined from actual industrial applications and have sufficient margin of safety that no appreciable heating will occur until the overload capacity of the brush has been greatly exceeded.

The Air Compressor in the Power Plant—I

By SNOWDON B. REDFIELD

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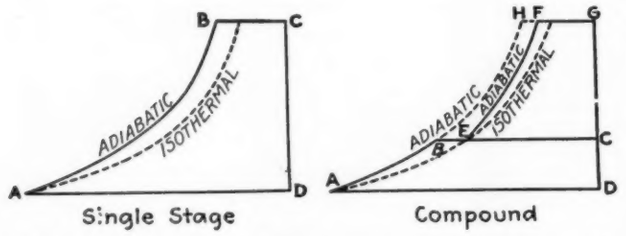
A FEW remarks as to the theory of air compression, and particularly the indicator diagram. The theoretical, single stage, no clearance, adiabatic (no cooling), no valve-loss indicator diagram is shown in Fig. 1. From *D* to *A* is the intake line corresponding to the atmospheric pressure. Adiabatic compression



FIGS. 1 AND 2. THEORETICAL COMPRESSION DIAGRAMS

takes place from *A* to *B;* at *B* the discharge valves open and the air is discharged from *B* to *C* at a pressure corresponding to the air system. At *C* the piston comes to rest, the discharge valves close and the pressure in the cylinder immediately falls to *D*, when the inlet valve again opens, to repeat the cycle. In Fig. 2 is shown a theoretical diagram of a compound compressor. In this case, at *B* the air is discharged along *BC* corresponding to the intercooler pressure. The length *BC* also represents the volume occupied by the heated, compressed air which was originally represented by the length *AD*, as cold free air. When the air *BC* has passed through the intercooler it has become cooled and the volume will be represented by length *EC*. If the intercooling has been complete, so that the air coming out of the intercooler is at the same temperature as that entering the low-pressure cylinder *AD*, the point *E* will be on the isothermal curve. The isothermal curve represents the relation of volumes and pressures if the air could be kept at the same temperature by some means of cooling all during the period of compression.

This article deals with the theory of air compression and with receivers, intake duct sizes, steam, air and water piping, regulators, lubrication and other things of interest to the man who operates air compressors.

The length *EC* then represents the volume of cooled air compressed to intercooler pressure which enters the high-pressure cylinder. Compression in the high-pressure cylinder then takes place along the adiabatic *EF* and discharge at line pressure takes place along *FG*.

As point *E* with complete intercooling is on the isothermal line, which started at *A*, it means that the product of the absolute pressure and volume at *E* is the same as the product of the absolute pressure and volume at *A*. Thus we can say

$$Abs.\ press.\ A \times vol\ AD = abs.\ press.\ E \times vol.\ EC,\ \text{or}$$

$$Abs.\ press.\ E = abs.\ press.\ A \times \frac{vol\ AD}{vol\ EC}$$

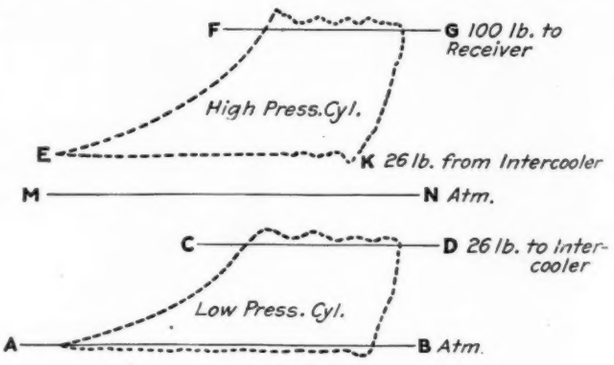
This means that the absolute intercooler pressure is the product of the absolute initial pressure (atmospheric) and the ratio of the cylinder volumes.

As an example, suppose that the low-pressure cylinder volume is 2.65 times the high-pressure cylinder volume, then the absolute intercooler pressure will be 14.7 $\times$ 2.65 = 38.9 lb. Subtracting 14.7 lb., the intercooler gage will read 24.2 lb.

If the compression had been single-stage, or even two-stage, *without any intercooling*, the entire diagram *AHGD*, which is the same as *ABCD* in Fig. 1, would have represented the work of compression. However, by compounding, giving a change for intercooling, the work is represented by *ABEFGD*, the saving by intercooling being area *BHFE*.

With compound compression to 100 lb. the theoretical saving is about 15 per cent of the single-stage work, and all of this saving is due to intercooling only. Excepting for the intercooling there is no saving of power by compounding, and unless a machine is properly designed the pressure losses through the valves and intercooler passages may largely offset the gain by compounding. A high-class compressor will show about 13 per cent saving in power over a single-stage machine at 100 lb. pressure.

Aside from power saving there are several other advantages due to compounding. One of these is a higher volumetric efficiency, because the amount of air trapped in the clearance spaces of the low-pressure cylinder at intercooler pressure will be less than if the pressure were of the discharge-pipe system. Another advantage of compounding is the condensation and separation of a good deal of the moisture in the air, and still another is the fact that with a compound unit the bearing pressures caused by the discharge pressure of each cylinder upon its own piston are much less than for compression in a single stage, with



FIGS. 3 AND 4. COMPOUND COMPRESSION ACTUAL DIAGRAMS

a machine of the same air capacity and same final discharge pressure.

In Figs. 3 and 4 are shown the actual indicator diagrams of a single-stage and a compound compressor of the plate-valve type. The lines *AB* and *MN* repre-

sent the atmospheric line in both cases, and *CD* and *FG* represent the discharge lines. The areas below *AB* and above *CD* and *FG* represent the excess work required to force the air through the valves, into and out of the cylinder. It is in the reduction of these excess areas that a great deal of the engineering talent is directed in valve improvements. At equal rotative and piston speeds a machine of the poppet-valve type will show much greater excess work areas on the indicator diagram than a plate-valve machine. There are other items, also, such as heating and leakage, that are of equal importance in the matter of economy. The elimination of all these bad features and the securing of durability, reliability and accessibility combine to produce a high-grade air compressor.

It is best to connect the piping the full size of the openings in the compressor. The outlets are designed in accordance with the pulsating discharge of the cylinders. Beyond the receiver the pipe lines may be smaller, because the flow will then be steady and non-pulsating, and the pipe sizes may be determined by the velocity to be allowed. The allowable velocity will depend upon the length of pipe and how much pressure drop is permissible. In various handbooks there are several formulas and tables for figuring pressure drop in compressed air flowing in a main. Ordinarily, for steady flow, a velocity of 2,500 ft. per min. is conservative where distances are short. Beyond the receiver this may be figured by the well-known formula,

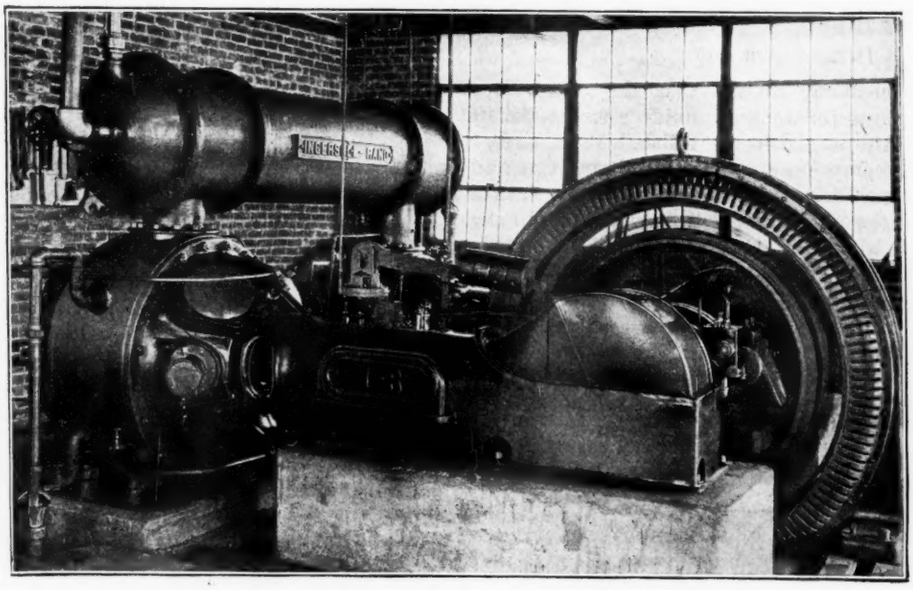


FIG. 5. DIRECT CONNECTED TWO-STAGE AIR COMPRESSOR WITH SYNCHRONOUS MOTOR AND CLEARANCE CONTROLLER

$$Quantity = Velocity \times Area, \text{ or } Area = \frac{Quantity}{Velocity}$$

In this case the quantity is the compressed air volume, and to obtain this we must remember that the volumes are inversely proportional to the absolute pressures and directly proportional to the absolute temperatures. The absolute pressure is obtained by adding the atmospheric pressure (14.7 lb. at sea level) to the gage pressure, and the absolute temperature is obtained by adding 460 to the Fahrenheit temperature.

With air at 100 lb. gage pressure, from a compound compressor, the temperature in the first part of the discharge pipe will be about 200 deg. F., so we have:

$$Compressed\text{-}air\ volume = Free\ volume \times \frac{4.7}{100 \times 14.7} \times \frac{200 \times 460}{60 \times 460}$$

This assumes that the initial temperature of the free air was 60 deg. F., which is a fair average, and we have

$$Compressed\ volume = \frac{Free\ volume}{6.15}$$

For a close figure we can then say the hot compressed volume of the air is one-sixth of the free-air volume when the pressure is around 100 lb.

As an example, suppose the compressor delivers 2,800 ft. of free air per minute, then the compressed air beyond the receiver will be about 466 cu.ft. per min., with air around 100 lb. gage pressure, and applying the formula,

$$Area = \frac{466}{2{,}500} = 0.186\ sq.ft.$$

or 26.8 sq.in., corresponding closely to a 6-in. pipe. Under these conditions the pressure drop will be a little less than ½ lb. per 100 ft. of pipe. For a longer distance 7-in. pipe would be better giving about 1,700 feet velocity and a pressure loss of 2 lb. per 1,000 feet of pipe. Based upon the pulsating flow directly from the discharge of the compressor, the intermittent velocity would reach a figure much higher than the assumption of steady flow would indicate. For this reason it is customary for some builders to provide much larger cylinder outlet connections for the pipe joining the cylinder and air receiver.

If there is a stop valve in the discharge line from the compressor it is essential that a good-sized safety valve be located in the pipe between the compressor and the stop valve. If this is not provided there is serious danger of starting the compressor with the stop valve closed, which may result in the bursting of the compressor cylinder.

The Air Receiver Should Be Near the Compressor

The air receiver should be as near the compressor as practicable, and there should be a separate pipe from each compressor to the receiver. The practice of connecting a battery of compressors to a long header pipe leading to a receiver outside the building is not good. Under certain conditions this produces pressure surges in the air moving down the long pipe, which materially increases the power required to drive the compressor. These surges require energy to produce and, as they serve no useful purpose, are a direct waste of power. It is better to have a receiver for at least every two

compressors and each machine connected through a separate pipe of its own, the piping to the receiver being as short as possible and the full size of the compressor outlet.

There is no established rule for the size of the receiver. If the character of the work is intermittent a more generous receiver capacity is advisable. However, it is possible in most cases to store only a relatively small amount of air in a receiver with permissible pressure fluctuation. A rough rule is to provide a storage of approximately one minute's supply of air. Thus for the 2,800-cu.ft. compressor we would have approximately 466 cu.ft. of compressed air per minute, so a cubic content of 400 cu.ft. would be liberal receiver capacity. This would be about 66 in. in diameter by 18 ft. long. The pipe leading the air from the compressor should enter the receiver near the top and leave near the bottom to assist separation of moisture and oil.

Intake Air Duct

Conditions of economy dictate that the compressor inlet should be connected to the outside air, instead of connecting with the engine-room cellar. It is a fact that the power to compress a cubic foot of air measured at intake conditions does not depend upon the intake temperature, but the amount of "stuff" delivered to the work (where the air is used) does depend upon this temperature.

To illustrate this, suppose that the compressor handles

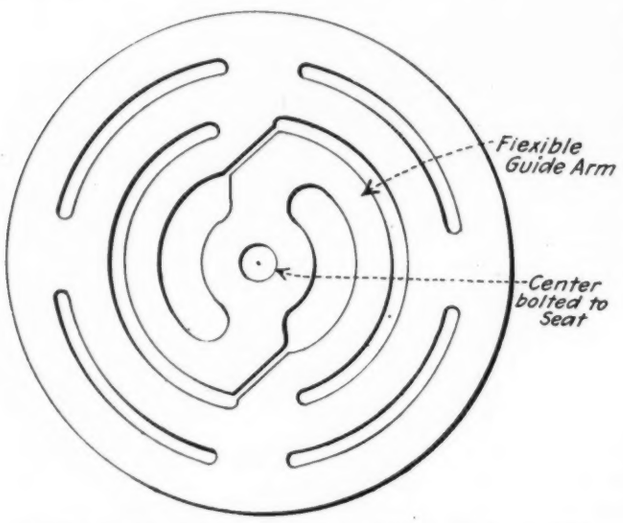


FIG. 6. PLATE VALVE, SHOWING FLEXIBLE CENTER

1,000 cu.ft. of free air per min.; let the season be summer and the engine-room cellar be at 100 deg. F., while the outside temperature is 80 deg. F. By the time the air reaches the work radiation will have cooled it to about 80 deg. If we take 1,000 cu.ft. of air from the engine room at 100 deg. F. this will amount to $1{,}000 \times \frac{80 \times 460}{100 \times 460} = 965$ cu.ft. of free air at the work. If this air had come from outside it would have been $1{,}000 \times \frac{80 \times 460}{80 \times 460} = 1{,}000$ cu.ft. of free air at the work. This is a gain of over 3 per cent in air quantity for the same amount of power expended or of fuel saved for an equal amount of air, in favor of the outside air duct.

Now assume moderate winter conditions: say, outside temperature 20 deg. F., engine-room cellar 88 deg. F. and final air temperature in the shop 73 deg. F. The 1,000 cu.ft. of air taken in from the engine-room cellar would then be, at the work, $1{,}000 \times \frac{73 \times 460}{88 \times 460} = 970$ cu.ft.; but if taken in from out of doors we have $1{,}000 \times \frac{73 \times 460}{20 \times 460} = 1{,}100$ cu.ft. delivered to the work. This is a gain of 14.4 per cent in air quantity, or fuel saved by the outside air duct. Averaging summer and winter temperatures the actual saving in a mild climate can thus easily be 8 to 10 per cent of the power. This is 80 to 100 hp. in 1,000, and is obtained by a simple air duct, which needs no attention or lubrication or upkeep when once properly installed. In a cold climate the saving would be even greater.

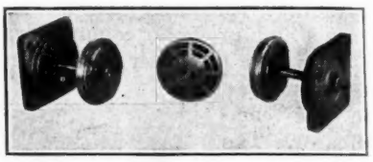


FIG. 7. PLATE VALVE COMPLETE

Mention was made that the intake duct should be properly installed. This should be emphasized, because the very heavy pulsations in an intake duct will destroy it if poorly built. A wooden duct is almost surely foredoomed unless constructed with extreme care and strength. A concrete duct, or large iron, steel or terra cotta pipe makes an excellent intake passage.

For intake ducts it is best to keep the velocities down. The lower the velocity the less the pulsations and the less the power consumed. A velocity of 1,600 ft. per min. is high enough except for very short intake pipes. If the pipe or duct is 20 ft. long it would be better to go even lower, say 1,200 to 1,300 ft. Being intake, or "free" air, the velocity may be figured directly from the uncompressed volume handled. For the 2,800 cu.ft. compressor an intake duct should have an area of not less than $\frac{2{,}800}{1{,}300} \times 144 = 310$ sq.in., corresponding to 20-in. diameter if round.

Not only is slow inlet velocity an advantage in reducing air friction and consequent pressure drop and power loss, but it also tends to stop the pulsations or pressure waves which often occur. Under suitable conditions these pulsations may actually serve to increase the volumetric efficiency and air output of a compressor by the inrush of air building up a pressure in the air cylinder just at the end of the suction stroke and the beginning of the compression stroke. It is sometimes claimed that volumetric efficiencies of over 100 per cent have been obtained by this means, but this is only "apparent" and by indicator diagram measurement. Actual air-quantity measurement by a nozzle will instantly show that the other losses, such as clearance re-expansion, heating of intake and leakage, tend to keep the actual air quantity appreciably less than the cylinder displacement.

Gain in volumetric efficiency by intake surge is not always to be desired, because the extra air has to be paid for in extra power and at no specially economical rate. This may even put a constant and troublesome overload on the electric equipment of a motor-driven unit.

One bad practice is to put the air-discharge pipes through the intake duct. This serves directly to defeat the gain of the cool duct, because the hot discharge pipe heats the incoming air. The writer knows of such an installation where the incoming air was heated 6 deg. F. by the presence of the discharge pipe in the intake duct. This was a direct throwing away of about 1⅛ per cent of power. Why deliberately throw away 11½ lb. of coal every time 1,000 lb. is shoveled into the furnace, all summer and all winter, day in and day out?

In estimating such a heating loss a rough figure is 1 per cent loss for each 5 deg. F. intake-temperature rise.

Steam Piping and Water Piping

In installing steam-driven compressors it is of course essential that steam pipes be amply large to avoid steam pressure drop. Another essential is a steam separator at the compressor steam cylinder entrance; connect this separator drain to a steam trap. Some of the most highly economical steam-driven compressors are built with piston valves, and it is well known that these valves cannot handle slugs of water as freely as the flat type. These piston valves, however, lend themselves to automatic cutoff governor control and to superheat, thus securing high economy. The steam separator is a good piece of insurance when properly drained to a trap; but it is curious to note that separators are sometimes seen without any drain pipe. What mysterious influence the operator attributes to such a device is hard to see.

Next in importance to air and steam piping comes water piping for jacket cooling and intercooling and sometimes aftercooling. The jackets do not need as much water as do the intercooler and aftercooler, as there is much less chance for absorption of heat through the jackets. The principal function of the water jackets is the preservation of the lubricant, while the intercoolers are a direct source of power saving. For every 10 deg. F. that the high-pressure inlet temperature exceeds the low-pressure intake temperature there is an increase of power of closely 1 per cent. Both intercooler and aftercooler serve to remove moisture from the air by condensation.

Jacket Water Should be Warm to the Hand

For the jackets of a compound unit the total water required for the two cylinders need not usually exceed 1 to 1½ gal per 100 cu.ft. of free air. Thus, with reasonably cold water (60 or 70 deg. F.) the 2,800 cu.ft. compound compressor could get along nicely on 35 gal. per min. for the two cylinder jackets alone. For the intercooler of a high-grade compound, 100-lb. unit, it is usually safe to figure on from 2½ to 3 gal. per 100 cu.ft. of actual free air. On this basis the intercooler of the 2,800-ft. unit would require from 70 to 85 gal. per min., if the intercooler were of efficient design.

For most compressors a water pressure approximating 20 lb. per sq.in. is usually sufficient, and if possible it is best to have the outflow water piping discharge into an open funnel. By this means both the quantity and temperature may easily be observed. It is best to adjust jacket water so that as it leaves it just begins to feel warm to the hand. Any more than this is really a waste of water and any less may quickly become hot and cause excess cylinder heating and oil carbonization.

Water for intercoolers and aftercoolers is best regulated by a thermometer in the *air* leaving the cooler. There is a point beyond which even an enormous increase in water quantity will not produce appreciably better intercooling. Of course all water jackets should be so piped that they may be completely drained to insure against freezing in case the engine room should become cold. All first-class compressors are designed to provide for this, but the water piping should be arranged to accommodate this condition also. This also applies with equal force to intercoolers and aftercoolers.

It is a good thing to clean out the sediment and scale which may accumulate in the jackets. Large machines often have handholes in the outer jackets to assist in this cleaning, and the occasional application of scrapers and a waterhose will help on all sizes. Intercooler and aftercooler tubes need this attention occasionally. Most coolers are made so that the tube nest may be removed for inspection, repairs and cleaning.

Regulator Piping

Piping which leads air to and from the various regulating devices deserves serious consideration. In the first place, as distances may be appreciable, it is well to provide good-sized connecting piping so that a sufficiently large volume of air may be passed to operate the regulators promptly. Certainly nothing less than ¾-in. piping should be used even for moderate distances.

There are two broad classes of regulators—those which control the speed of the compressor to suit the demand for air and those which regulate the air quantity independent of speed. In the first class come the Corliss engine-driven units and also the well-known type of "air ball governor." With these devices which take up definite positions relative to the air demand, it is usually essential to give them a little "life" or movement by connecting the pressure-regulating pipe to the discharge pipe of the compressor. By this means the pulsations of the air being discharged will serve to keep the governor parts in a condition of free movement. On the other hand, if the regulator is such that it does not operate until the air pressure reaches some definite predetermined point it is best to have the regulator as free from pulsations as possible by connecting the regulating piping to the air receiver. Unless this is done the pulsations may cause the regulator to go on and off many times due simply to pressure waves set up in the discharged air. If the connection is made to the receiver nothing will happen until a definite pressure is reached, and there should be no continued fluttering of the regulator.

Speed Control When Pressure Falls

With the governors that control the compressor speed according to the demand for air, there is usually a piston balanced by a spring or weight, or both, this piston being connected to the governor in such a way as to close or open the steam supply or alter the steam cutoff independently of the centrifugal part of the governor. In this type, then, the centrifugal action serves merely as an upper speed limit, and the compressor cannot exceed a certain speed no matter how low the air pressure may fall. Such a governor should be so adjusted that, if the air mechanism fails or the air pressure fails, the centrifugal mechanism will surely hold the machine within safe limits of speed. The air piston should move freely, but of course should not be such a loose fit as to allow leakage.

To prevent the governor piston from becoming rusted by the moisture that will come over with the air through

the regulator piping a small receiver should be provided to catch the water just before it reaches the regulator. This receiver may be easily constructed of, say, a 4-in. pipe about 12 in. long and closed at each end with a pipe cap. Standing this receiver on end, the regulator piping from the air system should enter the top and also leave from the top to go to the regulator. A drain valve should be tapped into the bottom of this small receiver and care taken that the condensed moisture is blown out of it at least once a day.

Of course the air piston of the regulator should be properly lubricated; a lubricator is invariably provided by the builder.

Relief Valves Reduce "No Load" Power

Regulators of the constant-speed class—that is, those which act suddenly at predetermined pressures—are often of the "all-on and all-off" type. With these regulators some form of pilot valve controlled by the air pressure acting upon a piston or diaphragm, resisted by a spring or weight, or both, admits air to the piston of the regulator proper. Thus, when the pilot valve has moved to a certain point, a port is uncovered that passes air to throw the main regulator piston. This piston moves a valve in the intake pipe, which closes off the air supply to the compressor, drawing a high vacuum and greatly reducing the horsepower of the compressor during the unloaded period.

With these regulators which close the intake it is often customary to provide some sort of automatic relief valve which at the same time opens the discharge to the atmosphere. This prevents excessively high compression of what little air leaks through the intake regulator, which would be from the vacuum in the intake to the full discharge pressure of the line. It also reduces the "no load" power, by compressing the air in the cylinder only to atmosphere instead of the full discharge pressure.

Owing to the undesirability of controlling large compressors of the electrically driven type by this sudden single step from full power to minimum power, there are some regulators built which control the machine in graduated steps. One of these as built by the Ingersoll-Rand Co. operates by adding clearance pockets to the ends of the cylinders, part of the air being compressed into the pocket and part being discharged as soon as the pressure in the pocket has reached discharge pressure. By providing four pockets for each cylinder, two at each end, each large enough to contain half the air in one end of the cylinder, it is so arranged that the unloading is in four steps: Three-quarter load, half load, quarter load and no load. With this type of regulator by the useful re-expansion of the pocketed air the reduction in cylinder power is in remarkably close relation to the reduction in air capacity, thus tending to high partial-load economy. In a compound unit the action is, of course, the same in both cylinders.

Advantages of the Step Controller

One convenient and economical feature of this four-step controller when used with electric drive is that it may be so set that at no time will the machine operate at more than a predetermined partial load. This is convenient for repair work at night or on holidays, when only a small amount of air is required. Thus, the machine may be so locked that it cannot take more than, say, half load, and so it is necessary to run a generator only large enough to take the smaller load. If this were not so arranged it would be necessary to run a generator of full capacity and this would run unloaded most of the time, and consequently with poor economy.

When electric power is purchased the unit rate is sometimes based upon the maximum demand, so that this form of stop or lock may serve directly to cut the maximum demand and thus the unit rate.

For some types of steam-driven compressors fitted with a speed governor and air-cylinder regulator it is customary to provide a steam regulator. This device is usually controlled by the same pilot valve which actuates the air-cylinder regulators, and its purpose is to slow the machine down to the minimum speed necessary to insure rotation during the unloaded period. By this reduction in speed while the air end is unloaded, less steam is consumed than if the centrifugal governor were allowed to maintain full speed.

Still another type of regulator for intermittent service with electric drive is the automatic start and stop. With this device a pilot valve or switch actuated by the air pressure starts and stops the motor automatically. Also, to relieve the motor of the heavy inrush of current at starting, special unloading devices unload the compressor before starting or after stopping. In this way the motor can start under light torque, and when at or near full speed the regulator is again automatically thrown to put full load upon the compressor, which then pumps air until again stopped by the controller.

Such an equipment as last described should be used only when very intermittent service is required, such as for fire whistles or for air charging an automatic sprinkler system. Care should be taken to keep all the electric contacts in good condition and to see that the starting unloader is in order so as to save the motor during starting periods and also to keep down the power consumption.

Direction of Rotation

One question always of interest is: What is the best direction of rotation for compressor? In a power-driven machine, in which all the driving power is applied to the shaft, either through a wheel or by a motor mounted on the shaft, the machine should run "under." Rotation in this manner with a power-driven machine tends to keep the crosshead down on the lower guide, preventing the knock that would be produced by the lifting of the crosshead if the guides and shoes became worn. Considering the outward stroke the crankpin draws the connecting rod outward and downward, and considering the inward stroke the crankpin pushes the connecting rod inward and downward. Thus the crosshead is held down on the lower guide.

The described series of motions and forces in a power-driven machine are usually easily understood, but the conditions in, say, a steam-driven compressor of the straight line, or tandem construction, are not so universally understood.

To study this matter, consider a tandem machine with the steam cylinder between the crosshead and the air cylinder, and imagine the machine to run "over," as in most steam engines. Starting with the outward stroke, the steam pressure in the steam cylinder is at its maximum and the air pressure at its minimum. Under these circumstances the excess power goes into the flywheels, causing the machine to accelerate; the thrust of the piston rod, with the rising connecting rod, certainly tends to depress the crosshead. Somewhat beyond mid-stroke the air pressure has built up and the expanding

steam pressure has decreased so that the steam and air loads may be equalized. At this instant all the steam power goes directly into the air piston. Beyond this point the air load will increase and the steam load decrease, so that the air load will far exceed the steam load.

The extra power now required to compress and discharge the air must come from the flywheels, having been stored therein at the beginning of the stroke as previously described. During this latter part of the stroke the power is coming from the crankpin, just as in the power-driven machine; but with the compressor running "over" in this case the crosshead will tend to rise.

Consideration of the inward stroke reveals the same situation: During the first part of the stroke the crosshead will be drawn down, and during the latter part of the stroke it will be thrust upward. If, now, the direction of rotation be reversed and the series of events again analyzed the same conditions will apply. For this reason a tandem steam-driven compressor may run either way so far as the raising or depressing of the crosshead is concerned. This applies equally well to cross-compound or duplex units. In the construction of certain machines, however, the builders have provided oiling devices that will function in one direction and not in the other, therefore it usually is essential to run the machine in the direction intended by the builders.

Compressor Lubrication

One of the most important items in running an air compressor is lubrication. In modern machines the running parts are usually inclosed in a crankcase and run in oil. The oil is made to circulate from the bottom of the bed over all the bearings, pins and guides and then runs back into the bottom of the bed again.

The air cylinders are sometimes lubricated by a sight-feed oiler so designed that the pulsation of the air pressure assists the feed of the oil. Also, sometimes the air cylinders are lubricated with a positively driven oil pump.

Two principles should be maintained in lubricating an air cylinder. The first is to use only the right kind of oil and the second is to use it sparingly. To be the right kind, air oil should be rather light-bodied and have a flash point above 300 deg. F. It should not carbonize under air-cylinder temperatures. These temperatures range around 260 deg. F. for compound compression to 100 lb. pressure and 360 to 375 deg. F. for single-stage to the same pressure.

How to Obtain the Right Kind of Oil for Air Cylinders

Probably the best way to secure the right oil for air cylinders is to buy oil specially made and recommended by only first-class and highly reputable oil concerns. Being in the business and having highly skilled chemists and engineers in their employ, as well as reputations to maintain, their judgment is usually a good guide. At any rate a short trial of a sample will soon demonstrate the quality of an oil for air-compressor service.

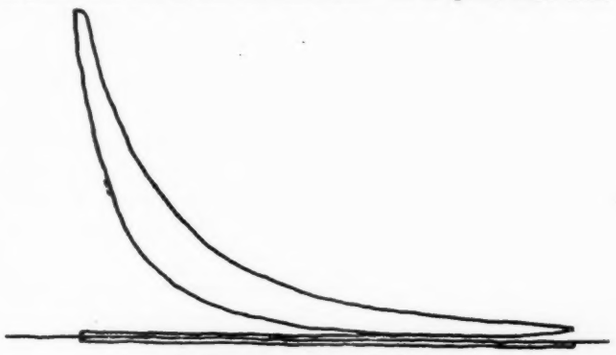
As to the second principle—to use the air cylinder oil sparingly—after a machine has been well run in three or four drops per minute are enough for a good-sized cylinder. If too much oil is used it will certainly result in excessive carbonization. Another evidence of too much oil is to see it coating the outsides of the cylinders and piping, having worked its way through the joints. This is bad practice.

One very important point is to see that the air receiver has all the accumulated oil drained out of it every little while. If too much oil is used or the receiver is not properly drained, gases may be formed which may ignite spontaneously and cause a bad explosion. This is a point that should be scrupulously observed in order to secure safety as well as continuity of service.

It is often recommended that a solution of soft soap or laundry soap and water be fed to the cylinder at stated intervals to clean out carbon deposit. This solution may be fed through the regular air-cylinder lubricating devices. Of course, after this treatment the interior of the cylinder may rust quickly unless the soap solution is followed up with oil for some time before shutting down. Never, under any circumstances, should kerosene or gasoline be used to clean out an air-compressing cylinder. Its use may easily lead to a disastrous explosion.

Excessive Back Pressure

A flour mill of 120 barrel capacity which is driven by a 360-hp. Diesel oil engine fails to mill up to its rated capacity. It was felt by the management that the engine was too small for the load. It is quite true that



EXCESSIVE BACK PRESSURE

a larger engine would have been more suitable. Nevertheless, with a proper installation the engine would have fully met the load demands.

Like most Diesel plants, no indicator cards were ever taken by the engineer. In fact no attempt was ever made to set the engine valves other than by measuring the valve rocker-arm clearances. In changing the atomizer the factory engineer had occasion to use his indicator. The diagram, taken from No. 1 cylinder, fairly represents the condition of affairs in all four of the cylinders. It is apparent that the exhaust valve opened entirely too late. This does not explain the excessive back pressure which served to lower the brake horsepower of the engine considerably. It was found that the exhaust pipe ran horizontally about fifty feet and then rose vertically along the wall of the flour mill. The total length of the exhaust line was more than 100 ft. and included two 90-deg. and two 45-deg. elbows. The pipe had not been increased in size to compensate for its length.

Unfortunately, no alteration has yet been made, and the engine, of course, still fails to carry the mill. In installing oil engines precaution should always be taken to secure a short exhaust line, although it should always be carried out of the engine room.

Some Milwaukee Plants of Interest

SINCE 1914, the year in which the annual convention of the National Association of Stationary Engineers was last held in Milwaukee, there has not been much new construction in the power plants of the city. The stations that were listed then in *Power's* convention number, Sept. 1, 1914, are still of interest, however, and worthy of a visit. Besides, a few small plants have been installed, and additions have been made to older plants which should be instructive to the visitor. As all engineers know, Milwaukee is a manufacturing city of the first rank with a varied line of products, many of which are equipment for the power plant. These manufacturers are well known, and an inspection of the shops and the products turned out will be welcomed. Also Milwaukee is one of the greatest coal-distributing points on the Upper Lakes, and its facilities for handling this fuel should prove attractive. Then there are the breweries with their large refrigerating and ice-making plants, the municipal pumping station at North Point, the tanneries, knitting mills, candy manufactories and a great variety of industrial plants of interest. Probably the one particular plant that will be of paramount interest is the powdered-coal installation at the Oneida Street Station of the Milwaukee Electric Railway and Light Co. As told in *Power*, March 2, 1920, five 468-hp. water-tube boilers are equipped to burn pulverized fuel and there is the necessary equipment for pulverizing, drying, conveying and blowing the fuel into the furnace. Through many vicissitudes and changes in furnace volume and shape, the installation has been brought to a satisfactory condition, where its operation compares favorably with the most modern and recent methods of combustion. The plant has created much interest in engineering circles and will be in full operation during the convention. By the same company construction work has been started on the new Lakeside Plant designed initially for burning pulverized coal. The initial installation is to consist of eight 1,306-hp. boilers supplying steam to 20,000-kw. turbines. The installation is not far enough along for inspection, but the story of the plant will be found on other pages of this issue.

It is to be expected that such an industrial city as Milwaukee will have many interesting power plants. The visitor will not be disappointed. The pulverized-coal burning installation in the Oneida Street Station is one of the most widely discussed in engineering circles. The largest station in the city is the Commerce Street plant. For labor-saving devices and apparatus for checking performance, the Phoenix Knitting Works takes first rank.

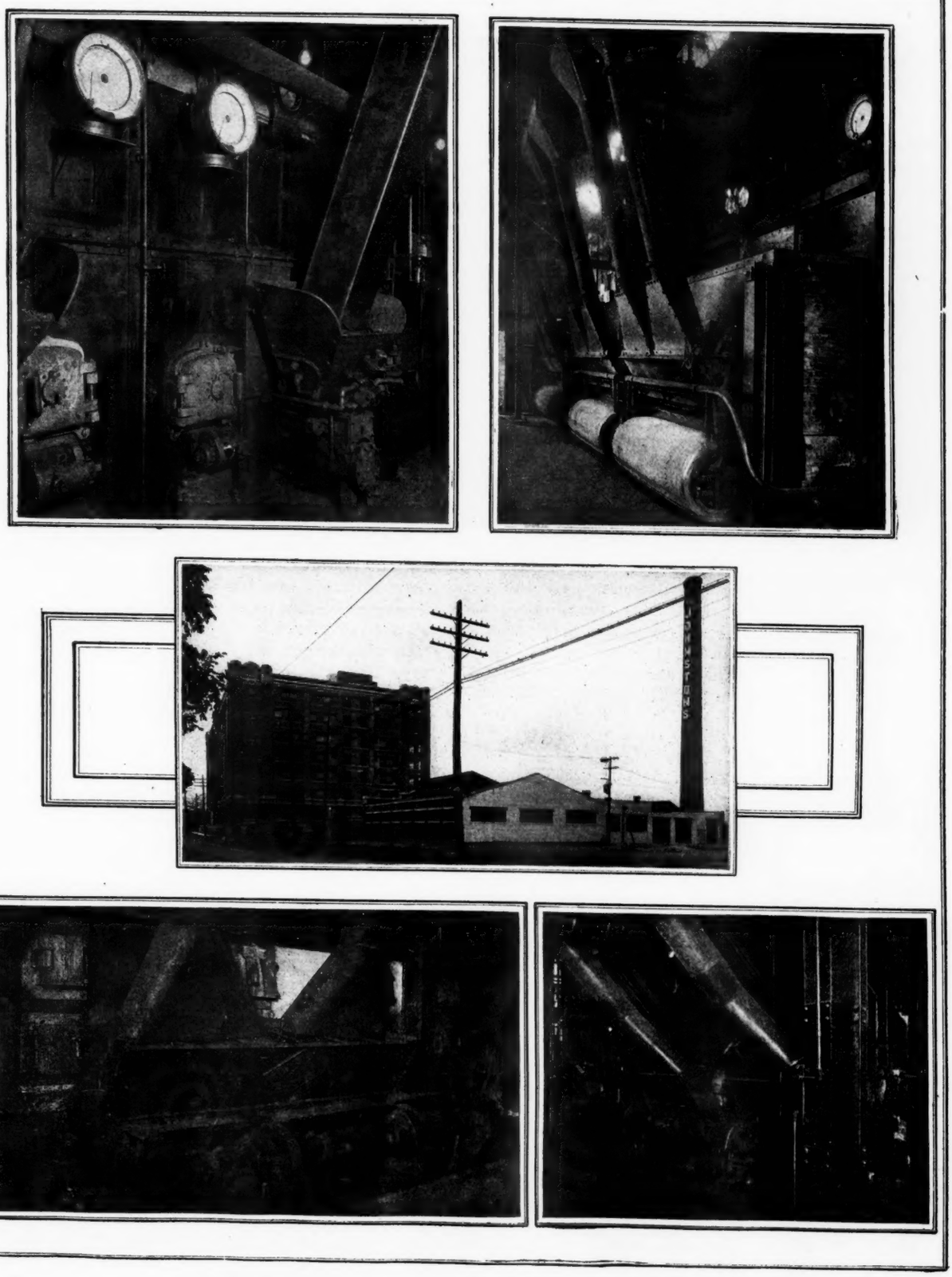
To those who have not had a previous opportunity, a visit to Commerce Street Station of this company should have its attractions. It is the largest power station in Milwaukee, having a generating capacity of 61,900 kw. and 17,000 hp. in boilers, but with its vertical engines, discharging into low-pressure turbines and its high-pressure vertical Curtis turbines, it ranks among the older stations. Since the last convention the only change of any moment was equipping 17 of the 24 boilers with new underfeed stokers. Depending upon the capacities of the boilers, these stokers use seven, eight or nine retorts, and each is driven through a silent chain by a variable-speed motor of the direct-current shunt type. One of these stokers is shown in an accompanying illustration.

One of the smaller stations of recent origin is the new power plant of the Phœnix Knitting Works. It has a capacity of only 750 hp., but is so completely furnished with labor-saving devices, meters and instruments that it is of decided interest. With the older plant, of 500 hp. capacity, it is serving seven of the ten buildings used by the company. The boiler room has four 300-hp. vertical water-tube boilers equipped with Type E stokers. Being a lake port, Milwaukee formerly received much of its coal from Pittsburgh and West Virginia, so that underfeed stokers are in common use. Of late, Elve screenings from southern Illinois have been burned with excellent results. The plant uses about 800 tons of fuel per month with an average evaporation of about 8 lb. of water per pound of coal and on test 8.92 lb. Each boiler has a steamflow meter, an efficiency meter, a CO_2 recorder used in common and a portable indicating instrument, a feedwater regulator, an automatic stop valve and dampen regulation at each uptake and the stack. There is overhead bunker service, the coal being elevated in a continuous bucket conveyor. Ashes are removed by a steam-jet conveyor. In addition the plant has a water softener, an open metering heater and an air-conditioning outfit with temperature regulation supplying 75,000 cu.ft. of washed air per hour to the mills. Exhaust fans draw out impure air.

In the engine room there is one unit, a 750-hp. poppet-valve engine driving directly a three-wire direct-current generator to supply the direct-current variable-speed motors in the mills. The plant is centrally located and the distance of transmission short, so that the line loss is comparatively low. The switchboard has the usual instruments and equipment and in addition a recording wattmeter to register the output. An engine stop protects the generating unit.

Because all exhaust steam is utilized the year around for drying, in the dyehouse, and for heating the buildings and feed water, the economy obtained in the plant is exceptionally high.

For years the Pfister & Vogel Co. has maintained one of the industrial show plants of the city at the Menominee Tannery. It has 3,100 hp. in horizontal reaction turbines, six water-tube boilers equipped with chain grates, an immense water-softening plant having a capacity of 150,000 gal. per hour and an air washer capable of supplying 40,000 cu.ft. per minute to the office building, with thermostatic control to turn on



VIEWS OF SOME INTERESTING POWER PLANTS IN MILWAUKEE

Top Left—Boiler Room, Phœnix Knitting Works. Top Right—Forced Draft Chain-Grate Installation Burning Coke Breeze, Milwaukee Coke and Gas Co. Middle—New Factory and Power Plant, Robert A. Johnson Co. Lower Right—Motor-Driven Underfeed Stokers, Commerce St. Station. Lower Right—Pawling & Harnischfeger Co. Boiler Room.

direct radiation when the room temperature drops below 70 deg. There are special facilities for coal and ash handling and in the basement a central hydraulic system for twelve elevators. At the Bayview Tannery, not far away, two 1,000-kw. turbines have been recently installed.

Pawling & Harnischfeger Plant

Farther west on the South Side is the new power plant of Pawling & Harnischfeger, which was put into operation early in 1918. It has 1,000 hp. in three water-tube boilers equipped with underfeed stokers driven by individual direct-current variable-speed motors. The forced-draft fans also are motor-driven. The operating pressure is 150 lb. and the superheat 125 deg. Artesian water for the boilers required a softening plant which is used during the four summer months when there are no returns from the heating system to give a pure water supply. Coal is handled by an electric monorail hoist from railway car to storage or to the overhead bunker. A steam-jet conveyor discharges the ashes into an open pit, from which they may be transferred to a railway car by the hoist previously mentioned.

In the engine room there are a poppet-valve engine driving a 500-kw. direct-current generator, a 100-kw. direct-connected Corliss unit and three air compressors. The plant is well equipped with instruments to indicate the efficiency of operation. It has differential draft gages connected over the fire and at the uptake, a CO_2 recorder, recording thermometers on the feed water and the steam lines, and a recording steam-pressure gage. A tunnel connecting the plant with the shop buildings carries on racks in the usual way the heating mains, the returns, water piping and the electric supply cables, the main distributing board being located in the shop.

Johnson Plant to Be Highly Economical

Two blocks away the Robert A. Johnston Co. is completing a new seven-story-and-basement factory building for the making of fancy biscuits and candies. It will be served by a power plant, installed in a building of its own, which should prove highly economical owing to utilization of the exhaust steam to the fullest extent. Exhaust steam supplemented by live steam will be required for cooking; it will be utilized for heating the building and in the operation of a 150-ton absorption system installed for the making of ice and the refrigeration of a chocolate-hardening room. The combination for utilizing the exhaust is thus ideal—heating in the colder months, refrigeration in summer and a constant demand throughout the year for coking. The economy should be many-fold that obtained in the average industrial power plant or in fact in the most highly developed condensing installation.

Four return-tubular boilers equipped with superheaters will supply steam at 150 lb. pressure and 150 deg. superheat. Rocking grates are temporarily installed, but provision is made for stokers, an overhead bunker and conveyor. A vacuum steam-jet system is to handle the ashes. There are two generating units driven by combination poppet-valve and uniflow engines, movement of a control valve determining whether the engine will operate on the counterflow or uniflow principle. The generators are 240-volt three-phase 60-cycle machines. Their output will be used directly for lighting and constant-speed motors. Direct current for variable-speed motors will be obtained through a 100-kva. synchronous motor-generator set. Effort has been exerted to make the plant attractive and to contribute to the comfort of the operating force by installing shower baths, toilets, locker rooms, etc.

A recent installation that has been attracting widespread interest in Milwaukee and vicinity is the four new water-tube boilers of the Milwaukee Coke and Gas Co., equipped with Coxe forced-draft chain-grate stokers for burning coke breeze. The boilers are rated at 412 hp. each. The two boilers first installed were furnished with stokers 8 ft. 8⅝ in. wide and 15 ft. long, giving an effective grate area of 130.5 sq.ft., which bears a ratio to the heating surface of 1 to 31.57. In the next installation and in the unit now going in the same width of stoker was retained, but the length was reduced to 13 ft. 8 in. The grate surface is thus 119 sq.ft. and the ratio to the heating surface 1 to 34.6. Through a series of gears the stokers are driven by 1½- to 3-hp. motors with a speed range of from 400 to 1,600 r.p.m. The boilers operate at 165 lb. pressure. They are equipped with steam-flow meters and, to afford a check, a venturi meter on the feed water. Overhead bunkers are provided.

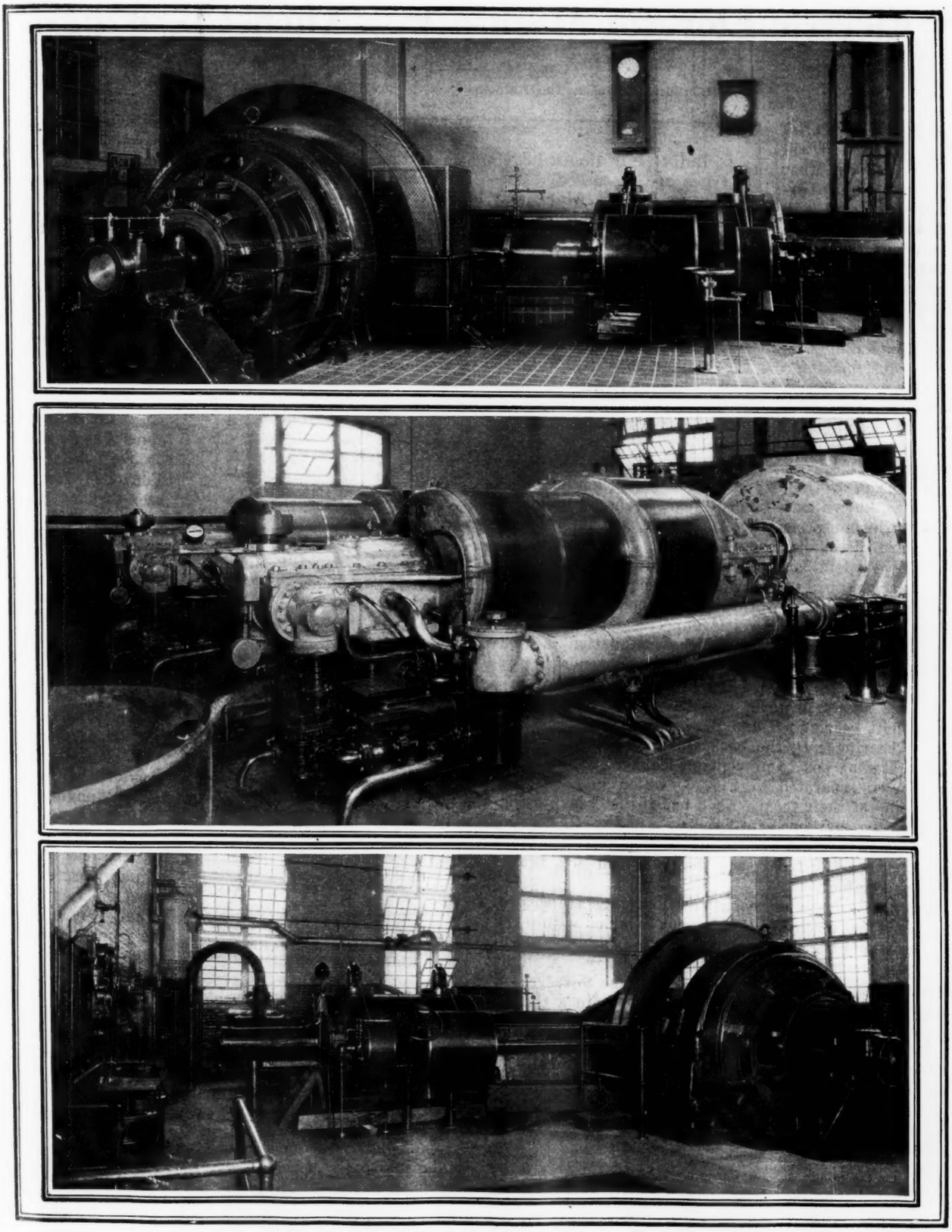
In daily operation the best results have been obtained at 150 per cent rating. The load is variable, dropping below this average at night and pulling up to 200 per cent of rating during the day. On ten-hour tests at 150 and 175 per cent rating conducted on the first two units, an over-all efficiency of 72 per cent was obtained when burning straight breeze having the following proximate analysis on a dry basis: Fixed carbon, 78 per cent; volatile, 7.57 per cent; ash, 14.43 per cent. The moisture in the fuel ran about 18 per cent. As fired, 24.5 and 27.7 lb. of breeze per square foot of grate per hour was burned at the two ratings given. On a dry basis these figures reduce to 20.11 and 22.8 lb., respectively. With the boilers operating at 150 per cent rating the ash analyzed 27.75 per cent fixed carbon, 0.31 per cent volatile and 71.94 per cent ash. The general operation has been most satisfactory, and with continued experience improvement is anticipated.

Eight Boilers Fired with Exhaust Gas

In the older part of the power plant there are eight waste-heat boilers running on the exhaust gas from the ovens. Steam is supplied to the generating and pumping plants. The exhaust is used partly for heating purposes and the remainder passes to mixed-pressure turbines to be converted into electrical energy.

The manufacturing end of the plant is most interesting and will be open for inspection. The company is a maker of furnace coke and is equipped to recover such byproducts as light oils, benzol, naphthalene, tar, ammonia and ammonium chloride, and when all byproducts have been recovered, the waste or surplus gas is sold to the city. The entire equipment, including a complete ammonia concentration plant, is interesting as the opportunity of viewing such an installation is seldom afforded.

Faulty oil distribution is probably the cause of overheating as frequently as anything else. The oil may be fed into the bearing at the wrong point or perhaps the grooves do not convey the oil to all parts of the bearing. The feed pipe may not be of sufficient size to supply the bearing with an adequate amount of oil or the oil reservoir may be too small to permit of proper cooling.



VIEWS OF SOME INTERESTING POWER PLANTS IN MILWAUKEE

Top—Generating Unit, Phœnix Knitting Works. Middle—Turbine Room, Pfister & Vogel Plant. Bottom—Generating Unit, Pawling & Harnischfeger.

Electric Elevator Machinery—Thrust Bearings

By M. A. MYERS
Electrical Engineer, The Maintenance Company, New York City

Ball-type of thrust bearings as well as button and dish types are discussed. These types are divided into two classes — those which are located on each end of the worm-shaft and those located on the free end of the worm shaft only. The assembling of these thrust bearings and their adjustment is explained.

OBSERVING Fig. 1, it will be seen that an overcounterweighted car will produce a forward thrust of the worm toward the motor, as shown by the arrow. It makes no difference if part of the counterweights are car weights, as the car is simply lightened by that much. Reverse the conditions, making the car heavier than the weights, and the worm thrust naturally changes toward the rear. Means must be provided to take care of these thrusts on suitable bearings in the gear case or otherwise, and the thrust bearings must be liberally designed, as their duty is severe.

A type of worm-gear reduction requiring no thrust bearings, known as a tandem gear, is shown in Fig. 4. Two worms and wormwheels are used, and the load and wear are distributed between them. The worms are respectively left- and right-hand cut, and the wormwheels are meshed to each other as well as to the worms. The thrusts of the worms being opposed and equal, the use of thrust bearings is unnecessary. Where the duty is severe and room for the installation is sufficient, the tandem-gear machine has commendable features.

Fig. 2 shows a worm complete with *A*, the front wormshaft bearing; *B* and B, the front and back ball-thrust bearings; *D*, the back wormshaft bearing; and *G*, the stuffing box to prevent oil leakage. These parts are shown separated in Fig. 3, which gives a clear indication of their form. Each ball-thrust bearing consists of two hardened-steel raceway plates, *P*, bearing respectively against the worm flanges and the front and back bearing faces; and the balls held in a bronze cage or retainer.

The parts of the wormshaft and bearings are so proportioned and machined that when assembled within the gear case and the worm bearings bolted fast, the worm will turn freely with practically no end play. A slight allowance must be made for expansion due to increased temperature in operation. A sixty-fourth to a thirty-second inch will be ample. Any slight adjustment may be made by varying the thickness of the gaskets under the worm bearing (or bonnet) flanges. For larger adjustments recourse is sometimes taken to filler plates or shims behind the steel raceways. The flange gaskets may be of paper, ordinary tar paper giving good results. Ball thrust bearings, properly fitted and liberally designed, should show little wear. If, however, through lack of oil, poor oil, grit or other reasons, the balls and races become worn and rough, the fact will be manifested in grinding, groaning or both, and the only remedy is new thrust parts, both balls and raceway plates.

Fig. 5 shows a system of alternate bronze and hardened-steel rings for the front, and alternate bronze and steel "buttons" for the back thrusts. They are assembled similarily to the ball thrusts just described. Such thrusts are made adjustable to take up the wear. The adjusting screw and locknut are located in the back wormshaft bearing. The front and back buttons are provided with integral "tongues" to fit in grooves in the end of the shaft and the end of the adjusting screw to prevent wear of either. Sometimes the front and back rings in the front thrust are likewise tongued or pinned, to prevent turning. The bronze buttons and rings are grooved for oil. This type of thrust bearing is being superseded to a large extent by ball thrusts. Occasionally, adjustable front thrust bearings will be found on the order of those shown in Figs. 6, 7 and 8. Fig. 6 shows what is known as the wedge thrust bearing, in which the inner edge of the front wormshaft bearing is

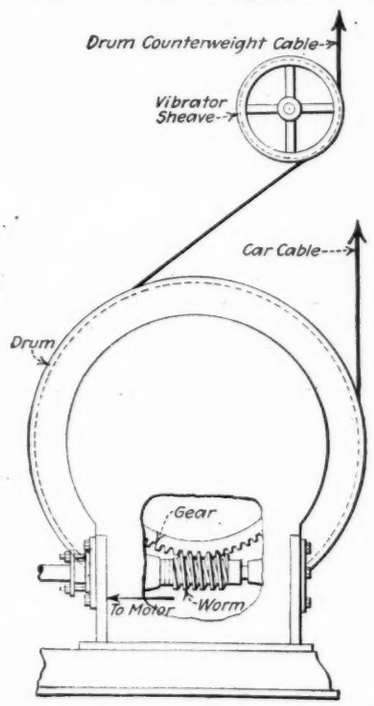


FIG. 1. SINGLE-GEARED ELEVATOR MACHINE

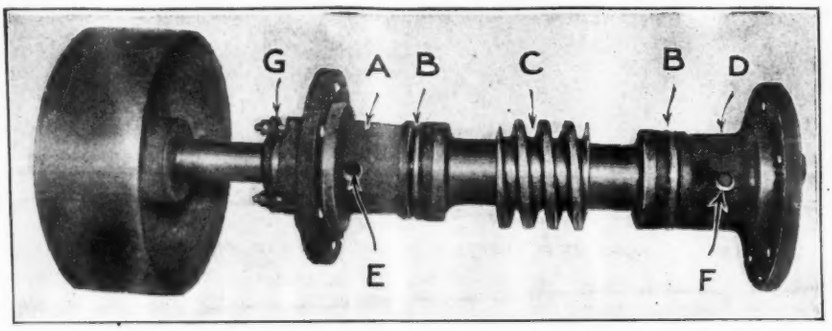


FIG. 2. WORMSHAFT AND THRUST BEARINGS

beveled as at *A*. A hollow wedge *W* encompassing the wormshaft is fitted to slide on this bevel and is held in adjustment by the adjusting bolts *S* and *S'*. The bearing edge has a squared projection or tongue *T*, which acts as a guide to the wedge. The thrust rings *R*, *R'* and *R''* are of bronze, between which are thin hardened-steel rings. The ring *R* is provided with four pins *P* which project within the hollow of the wedge, preventing the ring from turning but not interfering with the adjusting of the wedge. Ring *R''* is pinned to the worm flange as shown. If it is desired to adjust the worm toward the rear, it is only necessary to loosen the locknuts *NN'*, and unscrew *S*, and screw up *S'* until the desired position is obtained, and vice versa. Another type of adjustable front bearing thrust is shown in Fig. 7. *C* is a bushing machined to a good sliding fit in the front head *A*. The head is tapped for the adjusting bolts *S* and *S*, which are squared at *D* for a wrench and provided with threaded extensions for the stuffing-box gland *G* and which, at the other end are recessed into the sliding bushing, preventing it from turning. To adjust the worm toward the rear, simply loosen the stuffing-box gland and the locknuts *N* and *N*, and screw the adjusting bolts *S* and *S* in evenly, which will force the bushing *C* toward the rear. If it is desired to shift the wormshaft toward the motor, unscrew the adjusting bolts and bring up the worm by means of the rear-thrust adjusting bolt to the required amount.

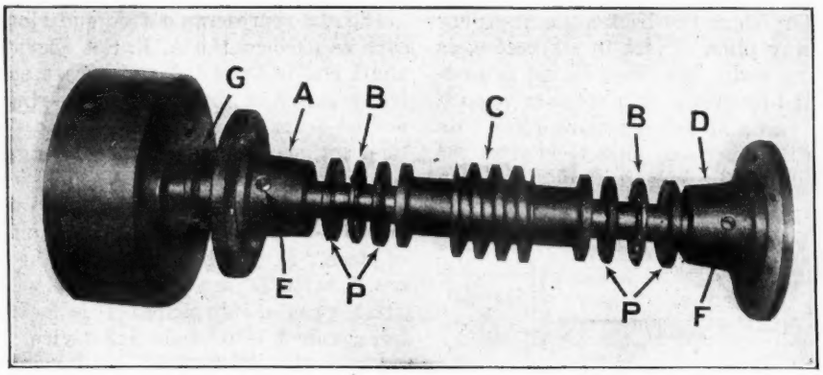


FIG. 3. SAME AS FIG. 2, WITH PARTS OF THRUST BEARING SEPARATED

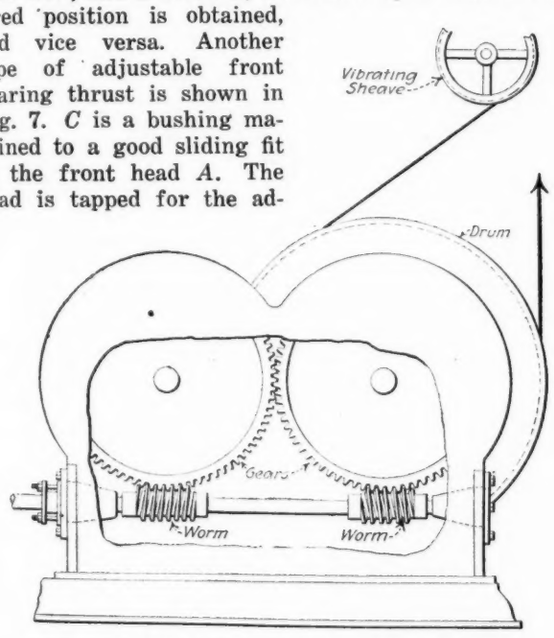


FIG. 4. TANDEM-GEARED ELEVATOR MACHINE

Fig. 8 is similarly adjusted by loosening the stuffing-box gland *G* and the large locknut *N* and screwing the threaded bushing *C*, which also constitutes the wormshaft bearing, either in or out as desired. In the cases of Figs. 6, 7 and 8, the back thrust bearing is an ordinary adjustable-button arrangement, similar to that shown in the rear wormshaft bearing of Fig. 5. In adjusting the front or back thrusts, care must be taken not to jam the wormshaft too tightly between them. A Hindley worm, which is curved to fit the arc of the wormwheel, as in Fig. 9, must, if it has adjustable thrusts, necessarily be adjustable both ways to keep the worm accurately centered, to avoid binding and cutting. To adjust such a worm the handhole of the worm case should be opened and the worm and wormwheel adjusted according to the manufacturer's markings.

The type of thrust shown in Fig. 5 has the advantage of sturdiness and simplicity. The disadvantage rests

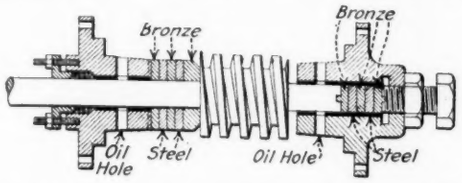


FIG. 5. WORM WITH STEEL AND BRONZE THRUST BEARINGS

in the fact that when the front thrust, which is usually the first to wear, must be repaired or renewed, it is necessary to remove the worm from the case to make such repairs or renewals. To overcome this objection, both thrusts may be placed in a case or bonnet at the end of the rear wormshaft bearing or, as it may be termed, at the free end of the wormshaft.

A patented adjustable thrust of this character is shown in Fig. 10. The free end of the wormshaft is turned down, as at *P*, and threaded with a left-hand thread for the combination double ball race and "bull ring" *F*. The end of the wormshaft is shouldered again at *Q* and threaded right-handed for the flanged locknut *H*. To assemble this thrust, the rear head *A* is bolted in place on the gear case and the front adjusting ring *C* is screwed in place into it. The raceway plate *D* is placed in the recess of *C* as shown. Then comes the first ball cage and balls *E*, after which the bull ring is

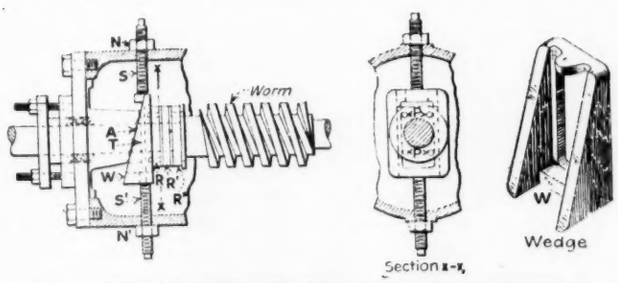


FIG. 6 WEDGE-TYPE ADJUSTABLE THRUST BEARING

screwed in place by means of a spanner wrench in holes *F* in its periphery. The washer *I* is placed and the locknuts *H* set up tightly. Then the second ball cage

E', is put in place, after which the back adjusting plug G, with the ball raceway plate D' set in its recess, is screwed into the casting end. The front-thrust adjusting ring is first adjusted by means of a spanner wrench in the holes x and x, cover M being removed for this operation. The adjusting ring and plug G is then set up by a spanner wrench in the holes x' and x' to give

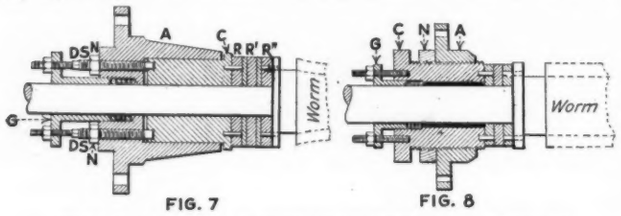


FIG. 7 FIG. 8

FIGS. 7 AND 8. ADJUSTABLE TYPES OF THRUST BEARINGS

the wormshaft the proper freedom without end play. Adjusting ring C and plug G are provided with a number of slots on their peripheries in which the setscrews K and K are set. The greater the number of slots the finer the adjustment. For example, if there are five threads per inch and twelve slots, adjustments of one-sixtieth of an inch will be obtained. The thrust case is finally filled with gear oil and the cover M bolted down. When the thrust is forward, the bull ring is pulled against the front balls; when the thrust is toward the back, the bull ring is pushed against the rear balls. In either case the thrust is transmitted through the raceway plates, the adjusting ring or plug, as the case may be, to the head, which, being bolted to the gear case, transmits the thrusts thereto.

A thrust bearing in which both front and back thrusts are taken by a single set of balls is shown in Fig. 11. The free end of the wormshaft is machined to a smaller diameter at P and threaded at the end Q The thrust parts in their installation order are the inner raceway plate C', which bears against the shoulder formed by the shaft reduction; ball cage with balls D; outer raceway plate C; filler plate E, which is keyed to the shaft by a Woodruff key; plain filler plate F; nut and locknut G, or there may be but one nut with a cotter pin through it and the shaft; and the bonnet H. With a forward thrust the raceway plate C is pulled against the balls and the thrust transmitted through C' to the head A. With a backward thrust C' is pushed against the balls and the thrust transmitted through C to the bonnet H, which is bolted to the head. Adjustments can be made by means of thin filler plates and varying the thickness of the bonnet gasket.

Fig. 12 represents a free end ring and button thrust such as used by the A. B. See Elevator Co. The wormshaft end is threaded and keyseated at P. The installation order is first the thrust ring R'' which is prevented from turning by pins into the head casting A; then thrust ring R' and thrust ring R, which is pinned to the "bull-ring" nut N and screwed with it to the shaft and the straight key inserted at P. Button B'' is pinned to the shaft end and is next put in place. B, which is pinned to the threaded adjusting cap C, with B' are put in place with the cap and the latter screwed into place. C is locked by a wrench-like arrangement W or a similar device. The thrust actions are directly against the head casting A for forward thrust and against the adjusting cap C for back thrusts.

Fig. 13 represents a type of ball cage used with perfect flat ground raceway plates, sometimes found in elevator machines. It is used to advantage when replacing ordinary ring thrusts with ball-bearing thrusts.

No discussion of elevator thrust bearings would be complete without mention of the old "prism" thrusts, Fig. 14, which are still to be found on old machines of the Otis Elevator Co. The general idea is to increase the wearing surface over that offered by plain button thrusts, by means of flanged bronze sleeves or bushings A, in addition to the hardened-steel buttons B, and pairs of small levers or prisms C and C,′ to equalize the thrusts between sleeves and buttons. Like with ordinary button thrusts, the back thrust T is located at the end of the wormshaft, but the front thrust T' is mounted ahead of the motor in a housing bolted to the motor bearing. The rear bronze sleeve bears against the worm flange and is prevented from turning by a tongue D on its flange, which fits into a groove in the back cast-iron bonnet. This sleeve also becomes the

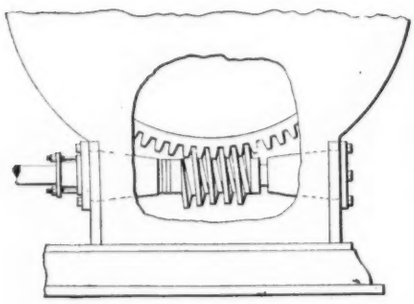


FIG. 9. HINDLEY TYPE WORM AND GEAR

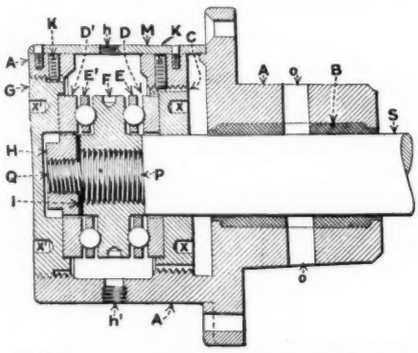


FIG. 10. ADJUSTABLE TYPE DOUBLE BALL-BEARING THRUST BEARING

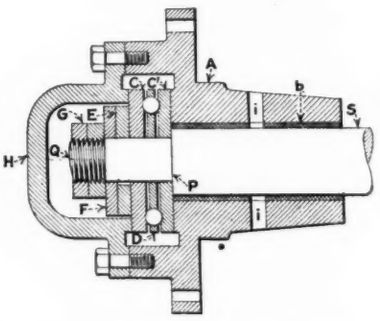


FIG. 11. ADJUSTABLE TYPE SINGLE BALL-BEARING THRUST BEARING

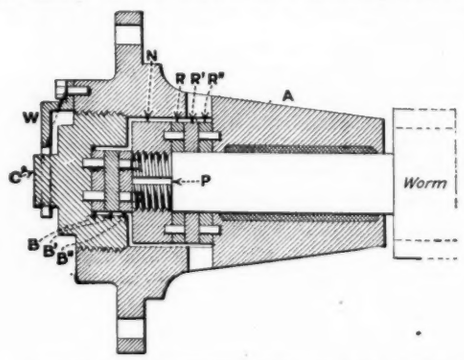


FIG. 12. RING AND BUTTON THRUST ON FREE END OF WORMSHAFT

rear wormshaft bearing. The front bronze sleeve bears against a hardened-steel ring *F* which in turn is fitted against a shoulder on the motor shaft and is held from turning by a round pin *P*. Two diametrically opposite tongues *E* sliding in slots in the bronze sleeves, prevent the hardened-steel buttons *B* from turning. The bronze sleeves are also slotted at *G*, into which the prisms fit

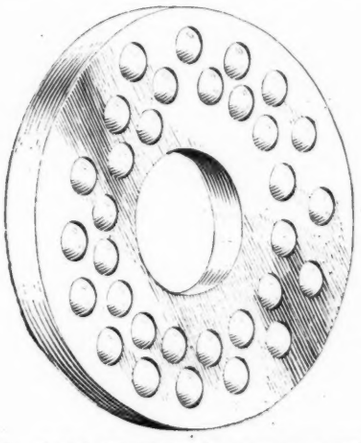


FIG. 13. BALL PLATE FOR THRUST BEARING

and are held in this position by the adjusting screws *H*. The knife-edge prisms or levers bear against the buttons and sleeves in one direction and against the adjusting screws in the opposite direction. An enlarged view of the prisms is given below *T* and *T'*, showing how they are designed to knuckle together. It will be seen that if the sleeves and buttons wear unequally, the prisms will tend to rock one way or the other, thus keeping the thrusts equalized between buttons and sleeves. Obviously, the thrusts may be exposed for inspection by merely removing the bonnets. Adjusting screws are often found screwed up tightly with several thin shims under their heads, instead of locknuts as shown in the figure. Adjustments are then made by simply removing or adding to the shims.

The combination brake pulley and coupling of these machines is split parallel to the shafts. In assembling, the armature is placed in its central position in the motor frame with its end thrust bearing applied and adjusted; the worm thrust bearing is also adjusted. A cylindrical fiber filler of the same diameter as the shaft is used to fill the space between the armature

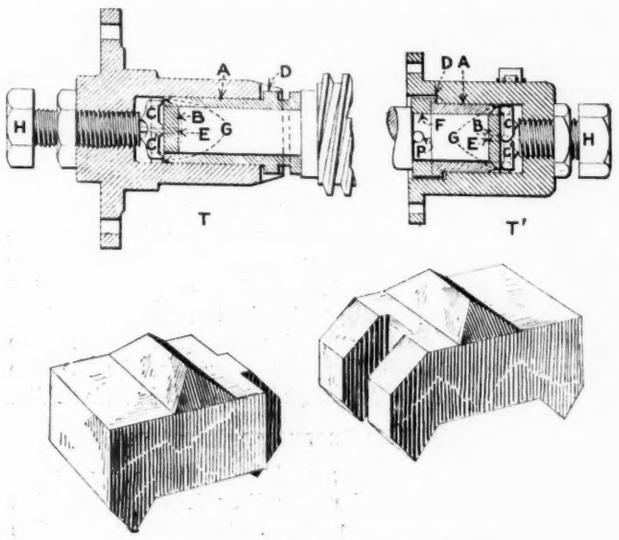


FIG. 14. PRISM-TYPE THRUST BEARING

shaft and the wormshaft, and the split-pulley coupling installed. It is sometimes found advisable, instead of adjusting the prism thrusts for backlash, to open the coupling and insert a longer fiber filler.

An elevator worm must not be allowed to have backlash. An apparently insignificant backlash rapidly becomes aggravated, and serious damage may result. When abnormal end play is noticed (and it is particularly noticeable when the machine is brought to a stop) immediate steps should be taken to adjust or repair the thrust bearings.

Effects of Voltage and Frequency Changes on Induction-Motor Operation

BY FRASER JEFFREY
Electrical Engineer, Allis-Chalmers Manufacturing Company

AN INDUCTION motor should not be used on a circuit of voltage different from that for which it is intended. If the voltage is high, the iron loss is increased and the copper loss decreased. If the voltage is low, the iron loss is decreased and the copper loss increased. These variations tend toward a localization of the heat either in the iron or in the copper, and if the variations are large enough ,the concentration rather than a distribution of the losses insures the liability of future burnouts and troubles. It should also be borne in mind that the torque of an induction motor, the frequency remaining constant, varies as the squares of the applied voltages, so that this feature has to be given due consideration in addition to the localized heating effects in either the iron or copper circuits.

If a motor designed for 60 cycles is operated at rated voltage on 50-cycles, the results are as follows:

The field strength is increased but the iron loss remains about constant. Magnetizing current is increased. The constant losses—core loss, windage and friction—remain approximately the same or, if anything, are slightly reduced, because, while the flux densities increase 20 per cent, resulting in a probable slight increase in core loss even on 50 cycles, the reduction in windage and friction at the lower speed is likely to more than offset any added core loss. The reactance on 50 cycles is lower than at 60 cycles, thus increasing the short-circuit current, starting and pull-out torques.

Assuming a constant horsepower output at either frequency, then the power factor is lower, owing to the increased magnetizing current, and the decreased power factor slightly increases the copper loss.

If anything, the efficiency will tend to increase slightly, but in general it may be stated that it re-

mains about constant because the total losses remain approximately constant. This latter naturally means that the motor temperature increases, because the speed and hence the natural ventilation are decreased.

The table shows some test results on a 5-hp. 440-volt three-phase 60-cycle 1,200 r.p.m. (synchronous speed) squirrel-cage motor operated on both 60 and 50 cycles.

CHARACTERISTICS OF 5-H.P. INDUCTION MOTOR WHEN OPERATED ON 60 CYCLES, ALSO 50 CYCLES

	60 Cycles 1,200 R.P.M.	50 Cycles 1,000 R.P.M.
Magnetizing amperes	2.8	3.7
No load loss in watts	300	270
Full load p.f. (5 hp.)	0.862	0.81
Full load eff. (5 hp.) per cent	85.2	85.2
Maximum starting torque in percentage of normal	176	245
Maximum starting current in percentage of normal	530	600
Maximum torque in percentage of normal	280	380
Hottest spot temperature rise, deg. C	35	43

Ordinarily, any reduction in speed should be accompanied with a corresponding change in the horsepower rating because it is obvious that a continuous rated motor with a temperature rise in the hottest spot of 50 deg. C. would get too hot at a lower frequency. The chances are that the terminal voltage would also have to be reduced to keep the temperature within safe limits.

Operation on Increased Frequency

Under these conditions and assuming a moderate increase in frequency, the opposite effects to operation on low frequency can be noted. The net result, the voltage and output remaining constant, is as follows:

The field strength is decreased, but the iron loss remains about constant and the magnetizing current is decreased. The constant losses, if anything, are increased, principally owing to the increased windage and friction at the higher speed. The reactance is higher, thus decreasing the short-circuit current, starting and pull-out torques. Power factor is higher, owing to the decreased magnetizing current. Copper loss is decreased because of the decreased power factor. Efficiency will tend to be lower, by reason of the increased constant losses, which are likely to more than offset the decreased copper losses. The heating will be less, owing to the ventilation being increased by the increase in speed.

Operation on Low Voltage

With the power output and frequency remaining constant, the effect of operating an induction motor on low voltage is somewhat the same as when operating on increased frequency. The chief difference comes in the localization of the losses as noted here:

The field strength and iron loss are decreased. Magnetizing current is decreased. Constant losses are decreased owing to the decreased core loss. The reactance remains constant, therefore the short-circuit current, starting torque and pull-out torque are decreased.

Owing to the decreased magnetizing current the power factor is higher. On account of the increased load current resulting from the lower voltage the copper loss is increased. The efficiency may be lower because of increased copper losses, which are likely to more than offset the decreased iron losses. Under the foregoing condition the worst feature of operation, provided the torque characteristics are satisfactory, is the fact that the added losses are not uniformly distributed but become localized in the copper, the iron losses actually decreasing. These copper losses increase as the squares of the currents and for this reason are likely to cause dangerous localized heating.

With the power output and frequency remaining constant, the effect of operating an induction motor on increased voltage is somewhat the same as when operating on decreased frequency. The chief difference comes in the localization of the losses as noted here:

The field strength and iron loss are increased. Magnetizing current is increased. Constant losses are increased, owing to the increased core loss. The reactance remains constant, therefore the short-circuit current, starting torque and pull-out torque are increased. Owing to the increased magnetizing current the power factor is lower. Since the voltage is higher the copper loss is decreased due to the decreased load current. Because the decreased copper losses are likely to more than offset the increased iron loss, the efficiency will be higher.

Under this condition of operation the losses are not uniformly distributed but are localized in the iron, the copper losses in this case being actually decreased.

Operation on Low Voltage and Frequency

If both the frequency and the voltage decrease, as when the speed of the supply alternator drops, the effects previously outlined are combined. Since the drop in voltage is accompanied with a simultaneous decrease in the frequency, the magnetizing current remains practically unchanged within certain limits. On account of the decrease in voltage the output decreases, but not as if the decrease in pressure took place without the accompanying decrease in frequency. The output decreases in direct proportion to the voltage and not as the squares of the voltages, as would be the case if the frequency remained unaltered.

An increase in frequency is equivalent to weakening the motor field, while a decrease is equivalent to strengthening it. On the other hand, a decrease in voltage tends to weaken the field, while an increase strengthens it, and if both voltage and frequency decrease together, the field strength will remain practically constant. The speed decreases, however, and the output becomes less.

Steel Melts From the Inside

"Steel Melts from the Inside" is the claim made by G. P. Blackiston, a practical steel man, of Canton, Ohio. Metal, before melting, is packed in pots. In the mixture used at the time of the discovery numerous pieces of octagon bar steel had been packed in pots and placed in the furnace. When the melting was well under way, one of the pots broke and was immediately removed from the furnace and set aside. After the pot was cooled, it was observed that chunks of metal were present which seemed to have the original shape they possessed at the time they were inserted in the vessel. Investigation showed the pieces to be hollow.

Pure iron has a higher melting point than steel, and the more carbon there is in the steel the lower its melting temperature. The outer layer of these bars of tool steel received the heat first, but this heat was, no doubt, immediately transferred to the inner portion. As the heat continued to be added, it is believed that the carbon was burned out of the outer layer and that it became, in fact, a low-carbon steel approximating iron itself. The inner layer still retained its carbon and would of course melt at a lower temperature, which explains why it had entirely melted while the outer layer was intact.

Rebabbitting Engine Parts—I

By H. HAMKENS
Consulting Engineer, Newton, New Jersey

The first of two articles giving complete and easily understood directions for rebabbitting engine bearings and other parts.

THERE are a few parts of an engine that keep an engineer guessing. One of theme is the babbitt in the bearings. A bearing will get hot once in a while for some reason or other, and if it is babbitted the question is, How long will the babbitt stand before

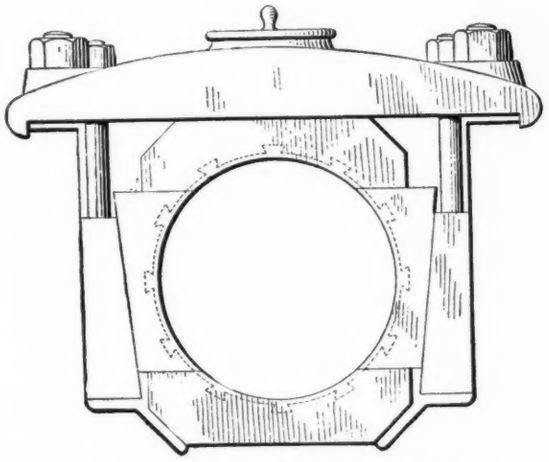


FIG. 1. COMMON TYPE OF MAIN BEARING

it begins to run? It may be nursed along with oil, grease, soap, graphite, water and even ice until the ominous little bright drops finally begin to ooze out at the sides or are spattered over engine base and floor and there is no help for it but to stop the engine.

Occasionally, the nursing process can be stretched out till "the whistle blows," when a "beautiful" job is waiting for engineer and helpers to replace the bearing or boxes, if he has been wise enough to provide for any spares; otherwise a job of rebabbitting is to be done, which is often carried far into the night. The principal parts of an engine that are lined with babbitt are the main bearing, outer bearing, crankpin boxes, crosshead shoes and occasionally eccentric straps and crosshead-pin boxes. In construction size and shape these vary greatly, as also do the methods of lining them with babbitt. The object of lining certain surfaces of an engine with babbitt is to prevent cutting, which is more liable to occur where two hard surfaces run together, and to make the surface renewable in case of water.

FIG. 2. BABBITT GROOVES FROM END TO END OF QUARTER BOX

In Fig. 1 a common type of main bearing is shown. It consists of lower and upper shells and two quarter-boxes. The principal wear is in the lower shell, next in the quarter-boxes; the wear on the upper shell on horizontal engines is negligible. The thickness of the babbitt in the shells varies, according to the size of the bearing, from $\frac{1}{4}$ to $\frac{3}{4}$ in. The babbitt is held in place by recesses, grooves, anchors or buttons of various shapes. The dovetailed grooves seem to be the favorite design. The size and number of the grooves vary, according to the diameter of the shaft, from $\frac{3}{8}$ in. at the narrow part for a 6-in. shaft to $\frac{3}{4}$ in. for a 24-in. diameter; the taper is about 30 deg. and the depth from $\frac{1}{16}$ to $\frac{1}{8}$ in. In some cases the babbitt and grooves are carried right through from end to end, as shown in Fig. 2, which is considered to be the best practice on large bearings. On bearings less than 10 in. in diameter the space for the babbitt is generally chamfered as illustrated in Fig. 3. This reduces the bearing surface somewhat and also exposes the shaft to being cut by the hard ridge at the ends if there is any considerable wear in the bearing. It is an excellent thing for an engineer to keep tab on the wear of the bearings. This can easily be done by making a gage from a fixed

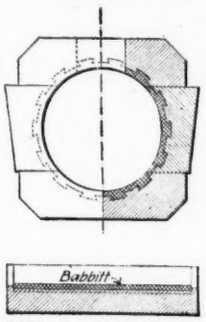


FIG. 3. SPACE FOR BABBITT CHAMFERED

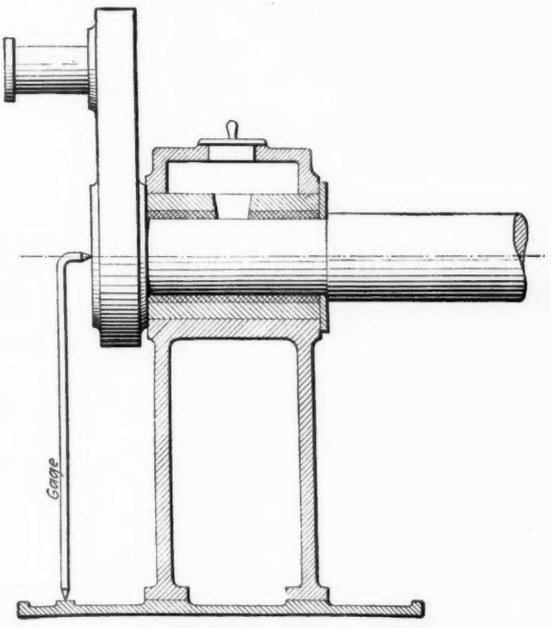


FIG. 4. GAGE FOR DETERMINING WEAR OF MAIN BEARINGS

point on the foundation plate or floor to the center of the shaft, as shown in Fig. 4, or by gaging the space between the upper box and the shaft by using a feeler. An occasional try will show whether the shaft goes down or not. The wear of the quarter-boxes can be ascertained by taking up the bolts at the end of the pillow block

or the wedge bolts if the latter construction is used. The customary taper of the wedges is $\frac{1}{8}$ in. per inch; therefore, if the bolts are $\frac{3}{4}$ in. in diameter with standard threads, 10 per inch, one turn of the nut or bolt advances the quarter-box $\frac{1}{10} \times \frac{1}{8} = \frac{1}{80}$ inch.

A conventional outer bearing for the smaller sizes is shown in Fig. 5. The wear is practically all on the

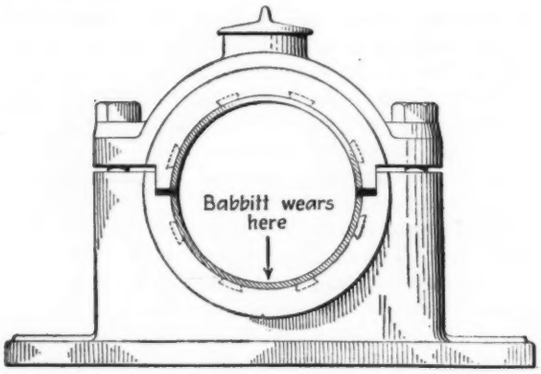


FIG. 5. WEAR OF THE OUTER BEARING IS ON THE LOWER BOX

lower box and can be readily measured on the outside. If a heavy flywheel is used for belt or rope transmission and located near the outer bearing, the latter is often subject to greater wear than the main bearing, which is due to the fact that the shaft rotates in the outer bearing always in the same position, while in the main bearing it is moved forward and back on horizontal engines.

Direct-connected engines are provided with more elaborate outer bearings, similar in construction to main bearings. As a rule they are well protected from oil leakage or dirt by means of shields and covers, as shown in Fig. 6. By removing the shield on the outside, the end of the shaft is revealed, and if anything goes wrong with the babbitt, it can immediately be detected. The lower shells are sometimes provided with wedges as a ready means of taking up wear, but although this is quite a convenience the practice seems to have been abandoned by engine builders. The tendency is to construct the bearings for quick and easy removal of the boxes, making the surfaces cylindrical, as shown in Fig. 7, instead of flat. Cylindrical shells can be rolled out by lifting the shaft slightly; the removal of a flat-bottomed box is often quite a problem. Unless there is room enough between the pedestal and eccentric to slip the box out below the shaft, the latter has to be jacked up sufficiently for the box to be rolled out, which means a lift of $\frac{1}{2}$ to 1 in. according to the size. This is quite a job on a direct-connected engine, for instance, having an air space of less than $\frac{1}{4}$ in. between armature and polepieces. Where the taking out of the boxes meets with difficulties, rebabbitting is put off as long as possible, often to the detriment of the shaft.

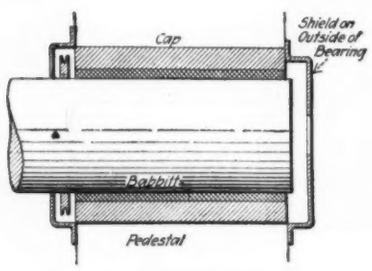


FIG. 6. OUTER BEARING FOR DIRECT-CONNECTED ENGINE, SHAFT PROTECTED BY SHIELD

While it is a simple matter to babbitt boxes in factories where all the facilities are at hand and where the work is done by men specially trained for it, it is different in an emergency case in the engine room. Still, there is nothing mysterious about it if some common sense and a certain amount of precaution are used. Cleanliness is here next to godliness, just as it is anywhere else. If the job is not to be done in a cleanly manner, it better be left alone, unless a man wants to take chances in pouring and have the metal thrown about and he get burned. Molten babbitt will not stand for any foolishness.

There are many kinds of mixtures that go by the name of "babbitt." The metals used to make babbitt

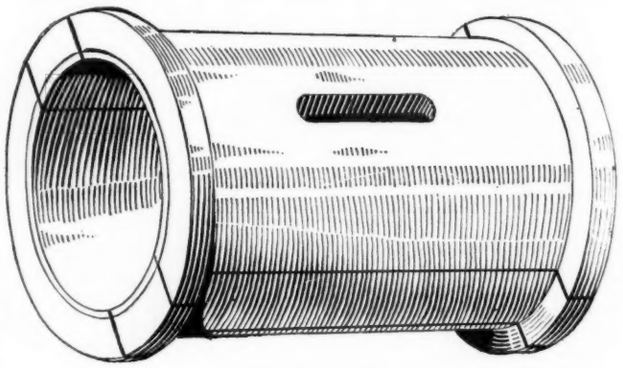


FIG. 7. CYLINDRICAL MAIN-BEARING BOXES

are tin, copper, antimony, lead and zinc, in a variety of compositions; different mixtures will serve different purposes. Anyone can make his own mixtures if he has the facilities. The accessories required to prepare a mixture without copper in small quantities are a forge,

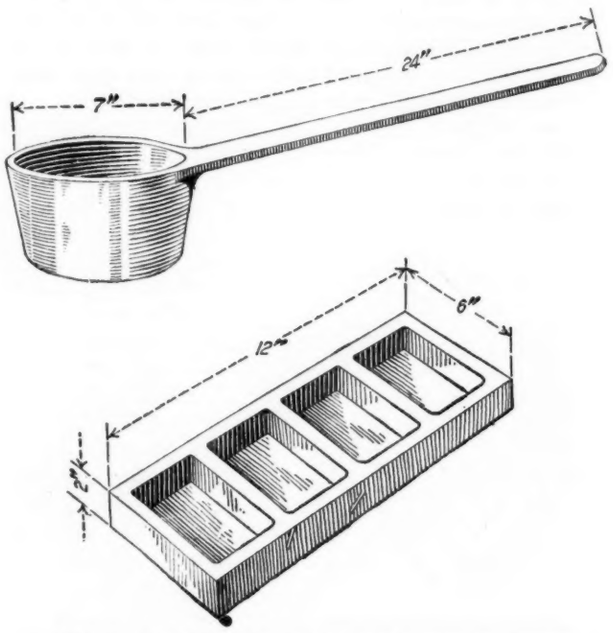


FIG. 8. LADLE AND INGOT MOLD FOR BABBITT

ladle and some ingot molds. A suitable ladle and ingot mold are shown in Fig. 8. For larger quantities and for alloys containing copper one or more crucibles and a furnace will be required. The composition of genuine babbitt is generally taken to be 89 parts tin, 3 copper

and 8 antimoney. This is a good all-round mixture, largely used on engine work; its expense is a small item where wearing quality is to be considered. Copper requires a high temperature for melting. For this reason for repair jobs alloys of zinc and tin in the proportion 80 zinc to 20 tin, or of lead, antimony and zinc in the proportions of 78, 20 and 2 may be used for moderate pressures and speeds. The metal having the highest melting point is melted first, and the others are added gradually. The molten mass must be stirred to make the mixture uniform; otherwise the heaviest metal, like lead, will remain at the bottom.

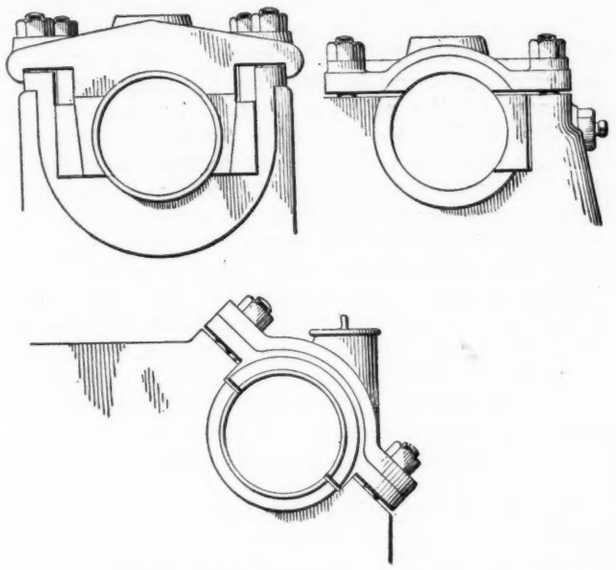


FIG. 9. TYPE OF MAIN BEARING WITHOUT REMOVABLE BOTTOM BOX

Large numbers of engines are running without any removable boxes in the main bearing; others are provided with one or two quarter-boxes. The different designs are shown in Fig. 9. To rebabbitt bearings of this kind it is necessary to remove the shaft, then cut out all the old babbitt and clean out the recess in the pillow block. If no proper mandrel is available, the bearing can be rebabbitted by using the shaft, if it is in good condition, although this is not considered good practice. In case the shaft is to be used it must be blocked up in position, as shown in Fig. 10, "A," and for the particular bearing shown wood strips and blocks are inserted in the pillow block, and molding sand or fireclay rammed in on the sides, with regular gates and vents for pouring the metal. Care must be taken to keep sand and dirt out of the space for the babbitt. The shaft should be warmed before the metal is poured. All openings at the crank and collar must be closed with fireclay to keep the babbitt from running out. The metal is poured from one or both sides according to the size of the shaft.

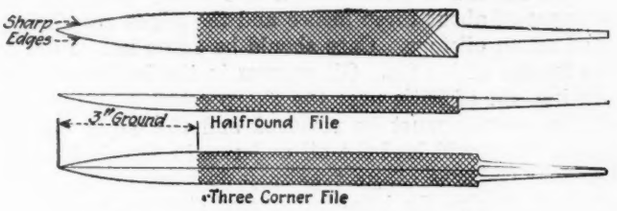


FIG. 11. SCRAPERS MADE OF OLD FILES

After the bottom of the bearing has been poured, the clay or sand must be removed and the space for the quarter-boxes cleaned. The latter are then put into place and secured with wooden blocks, as shown in Fig. 10, "B." Pieces of thin asbestos board are generally placed under each box to keep the babbitt apart, and after all openings at the ends have been closed the babbitt is poured into the boxes. Finally, the cap is put in place and the babbitt is poured either through

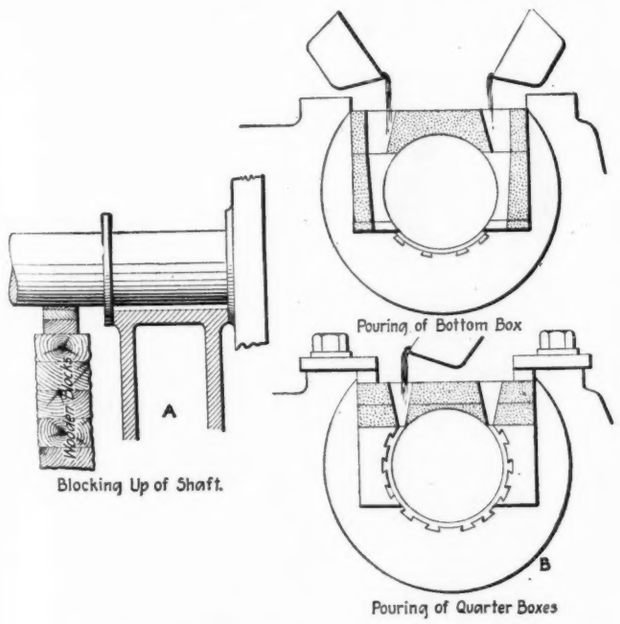


FIG. 10. METHOD OF BLOCKING UP THE JOURNAL AND POURING THE BABBITT

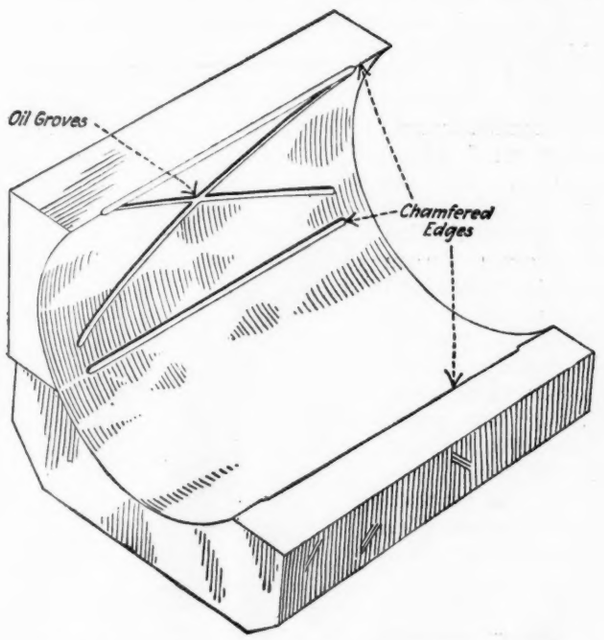


FIG. 12. CHAMFERED EDGES AND OIL GROOVES

openings in the top or through gates at the ends. It is essential that all parts with which the new babbitt comes in contact must be warmed, otherwise the metal will be chilled and not fill the boxes.

The next thing in order will be the removal of cap and boxes and a thorough cleaning of the pillow block. The shaft should be lifted high enough so that the bearing can be scraped; quarter-boxes and cap must also be scraped and fitted to the shaft. A good scraper can be made from a half-round file or from a good-sized three-cornered one, as shown in Fig. 11. In each case the end of the file is ground on a fine emery wheel for a distance of about three inches and the edges are sharpened on an oilstone. Care should be taken not to draw the temper of the file. Oil grooves in the bottom of the bearing are of little use; the sharp corners at the top of the grooves must be removed and the edges chamfered. This will lead the oil underneath the shaft. In the quarter-boxes oil grooves may do some good; their object is to give the lubricant a good start on its downward course. Fig. 12 shows the chamfering of the edges of the lower bearing and quarter-box and the oil grooves in the latter. The grooves may be cut with a cape chisel and smoothed with a round file.

Maintaining Correct Average Frequency

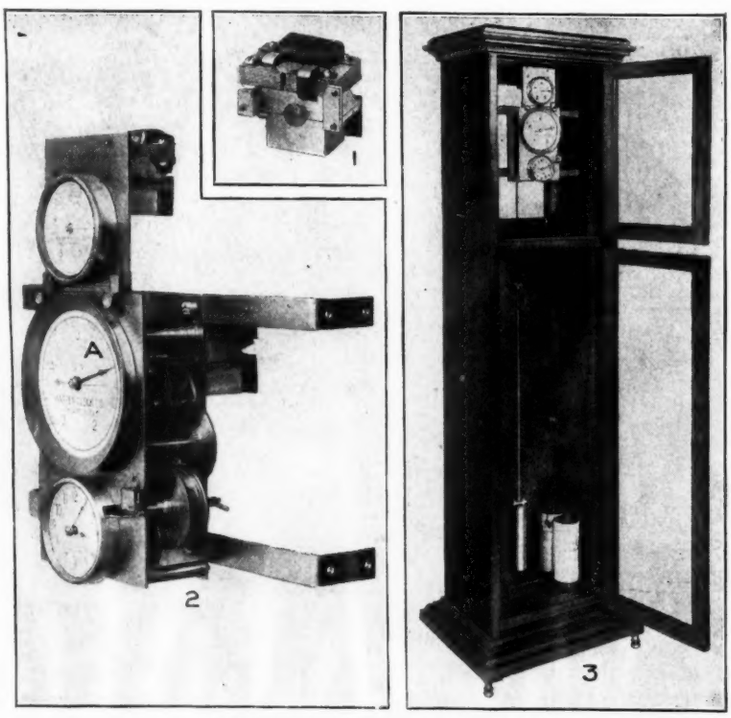
In synchronous motor application the latest departure is the installation of a very small self-starting motor in a clock, where it is used, in connection with a high-grade clock movement, to compare the speed of a synchronous generator with exact time, in order to give a continuous check on generator frequency. Since any change in the speed of the generator is reflected in the speed of this small motor, whereas the clock speed remains constant, the combination forms an accurate method of maintaining constant average frequency.

These small motors can also be used on the system in place of clock mechanisms to drive graphic recording instruments, demand meters and time switches. By the use of this motor the synchronization of records from graphic meters and demand meters will be made possible — something that has always been desirable, but somewhat difficult of accomplishment heretofore. In practice a master clock, Fig. 3, containing two movements, one electrical and one pendulum-operated, is located near the switchboard. The face is equipped with two pointers, one black, the other gold, rotating independently about the same center, on a dial *A*, Fig. 2, called the operating dial. The black pointer is so geared to the pendulum clock as to make one complete revolution every five minutes. The gold pointer is geared to the small synchronous motor so that when the frequency is correct it will rotate at the same speed as the black hand. All that the operator has to do is to hold the two pointers together—he will then have a fixed relation maintained between standard time and generator speed, or cycles and time. This can be done by adjusting the speed governors of the prime movers. The master clock does not obviate the use of a frequency meter, or indicator, since it will not show instantaneous fluctuations in speed. Moreover, by using a frequency indicator near the master clock the latter may be used as a constant check on the accuracy of the former.

The little synchronous motor, Fig. 1, which is the vital part of the electric component of the clock, is only $2\frac{1}{8}$ x $2\frac{5}{8}$ x $2\frac{3}{16}$ in. in size, and is wound for operation on a 110-volt circuit. It consumes less than 4 watts at 110 volts 60 cycles, but can be made for any one of the standard commercial frequencies. It is self-starting under load, reaches synchronous speed in less than a second and holds speed as long as the current is uninterrupted.

There have been developed two forms of master clock, known as the type "A" and type "B." The principal difference in operation is that in the "B" type both the motor and the clock mechanism act on the same index hand, through gearing, so that the synchronous motor tends to drive the hand in one direction, while the clock mechanism tends to drive it in the opposite direction.

If the rate of the clock and motor are the same the hand rests at zero on the scale, but if the speed of the motor varies the hand is moved slowly in a clockwise or counterclockwise direction according to whether the variation is a gain or loss in speed. In this way the clock is caused to indicate variations in average frequency. The installation of these master clocks will not eliminate fluctuations which are dependent to some degree on load variations, speed-governor response or steam pressure — features of operations that are more or less constantly encountered—but it does insure the maintenance of a more uniform as well as correct average frequency. The clocks and motors are manufactured by the Warren Clock Co., Ashland, Mass., and are being handled by the General Electric Co., Schenectady, N. Y.



FIGS. 1 TO 3. CLOCK FOR CHECKING GENERATOR FREQUENCY
Fig. 1—Self-starting synchronous motor for use in clocks. Fig. 2—Clock dials and mechanism. Fig. 3—Frequency clock complete.

The Care of Refrigerating Plant Auxiliaries

By B. C. HILL

THE liquid receiver is a tank usually mounted up on the wall in the engine room or on the roof, and if on the roof, generally under the ammonia condenser. The builders of recent types of ammonia condensers seem to have lost sight of the fact that the reduction in condensation surface from one-half to one-third required for the older types has also cut down the liquid-holding capacity or storage capacity required to take care of "pump-outs" in case of trouble. There have been a number of instances where the writer has found it necessary to install additional receiver capacity, as it was found that when the receiver was shut off for pumping down or shutting down to make minor repairs, it would be filled to capacity and the liquid would back up to the condenser, cutting down the condensation surface to such an extent that the condensing pressure would rise from a normal of 150 to 160 lb. to 200 or 220 lb. in five or ten minutes, making it necessary to slow down the compressor.

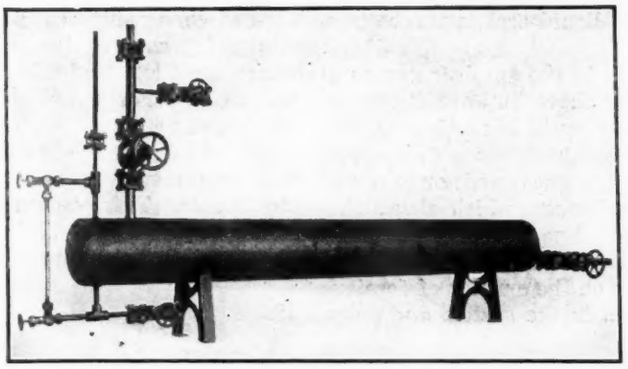


FIG. 1. TYPICAL AMMONIA RECEIVER

There is no fixed rule for the size or holding capacity of a receiver. In the writer's work the receiver capacities have been increased to a ratio of about one-fourth cubic foot to one ton of refrigeration, or say about 432 cu.in. per ton, which experience shows is satisfactory and ample to take care of pumping out the refrigerating coils without unnecessarily raising the condensing pressure. Another important use I have made of the liquid receiver for many years is as an air or foreign gas extractor. The velocity of the liquid passing through the liquid line from the condenser to the receiver will carry a portion of the noncondensable gases to the receiver, and while the plant is in operation the flow is continuous from condenser to receiver, which will not allow the gases to ascend through the liquid line to the condenser until the plant is shut down; provided, however, that the liquid is high enough in the receiver to seal the line leading to the evaporating coils. In this case the noncondensable or foreign gases can be drawn off at the top of the receiver by placing a ½-in. extra-heavy short nipple and valve, so that these will not be easily broken off, and then reduce from ½ in. to ¼ in. and run the latter line to some convenient place and submerge it in a bucket or barrel of water. Next, open the half-inch valve slightly, and if bubbles appear on the surface of the water, there are gases in the system other than ammonia, and they can be worked out slowly while the plant is in full operation.

As already explained, some of the noncondensable

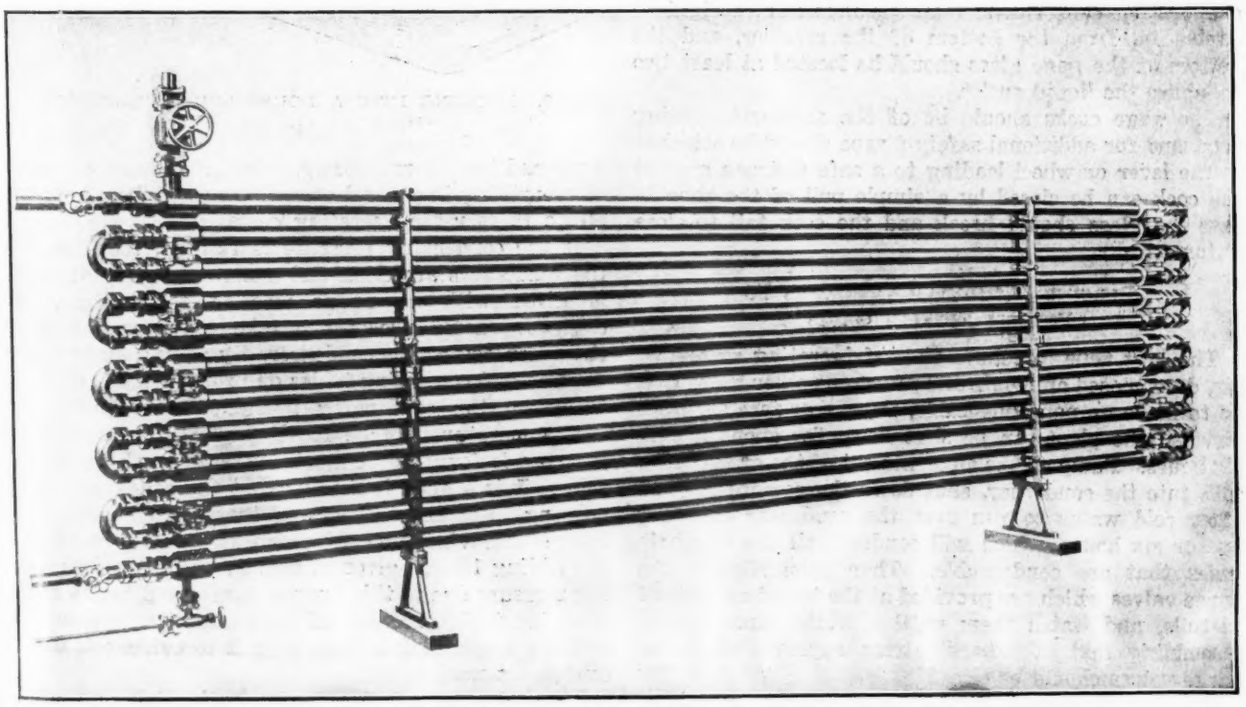


FIG. 2. DOUBLE-PIPE AMMONIA CONDENSER

gases are carried from the condenser to the liquid receiver, and if the outlet from the receiver to the evaporating coils is sealed, they will be trapped in the receiver because they cannot get out at the top of it while the plant is in operation, nor can they get out at the bottom on account of the liquid seal to the bottom outlet.

This trapping of the gases in the receiver causes a slight pressure in the receiver above that of the incoming liquid, and as the outgoing liquid is continuous, the liquid level in the glass will gradually drop to a point where the bottom opening will be uncovered; or in other words, the liquid seal will be broken, which allows the gases to pass out into the liquid line, reducing the pressure in the receiver and generally filling the glass gage to the top or above, depending on the amount of foreign gases, the amount of ammonia in the system and upon the working conditions.

Clean-out Line from Liquid Receiver and Oil Traps

The clean-out connection to the receiver should be made at the bottom and extend up inside in a vertical position a distance of six to eight in. The six or eight in. of pipe that extend inside the receiver should have a running thread cut or have the pipe turned down in a lathe, small enough to pass through a standard-size tapped hole. Before making-up the pipe in the receiver, however, have a plug welded in the end of the pipe so it faces up, and then perforate it with enough ½-in. holes to at least equal the area of the line. The plugged end and perforations will insure against the line stopping up, as more or less rust and dirt will always work through the system and lodge in the liquid receiver and oil trap. For this reason the clean-out line on the receiver should be opened at least once a week to make sure that it is not stopped up, and on the oil trap the clean-out line should be opened every day to remove oil, if there be any, and to make sure that the line is clear.

The liquid outlet line leading from the receiver to the evaporating coils should take the liquid from eight to twelve in. from the bottom of the receiver, and the bottom of the gage glass should be located at least two in. above the liquid outlet.

The gage cocks should be of the automatic closing type, and for additional safety a rope should be attached to the lever or wheel leading to a safe distance so that the cock can be closed by a simple pull of the rope in case the glass should break and the cock fail to close automatically.

Purging Ammonia Condensers To Remove Foreign Gases

The best time to relieve the refrigerating system of air, decomposed ammonia and numerous other gases that go to make up noncondensable, impure or foreign gases is when the plant can be shut down for about five or six hours. Pump all the ammonia out of the evaporating coils into the condenser, shut down the compressor and allow cold water to run over the condenser coils for five or six hours, which will condense all the ammonia gases that are condensable. Then open slightly the purge valves which are provided at the top of each stand of coils, and watch them until a white vapor closely resembling that of exhaust steam appears, when the purge valves should be closed.

Purging condensers is necessary to the successful operation of a refrigerating plant, but is not a "cure-all" and should not be overdone, as it is an item of expense that runs into considerable loss of ammonia and money.

Excessive condenser pressure is caused by an over-accumulation of non-condensable gases, dirty condenser coils, insufficient supply of condensing water, temperature of condensing water too high for the amount of condensing surface, too much ammonia in the system; where the Block and other similar types of condensers are used, a shortage of ammonia will cause high condensing pressure.

It is the engineer's business to know, in case the condensing pressure is running too high, what is causing the trouble. This pressure should at all times be kept as low as possible, as high pressure means more power, more coal, more ammonia leaks, more blowouts, more

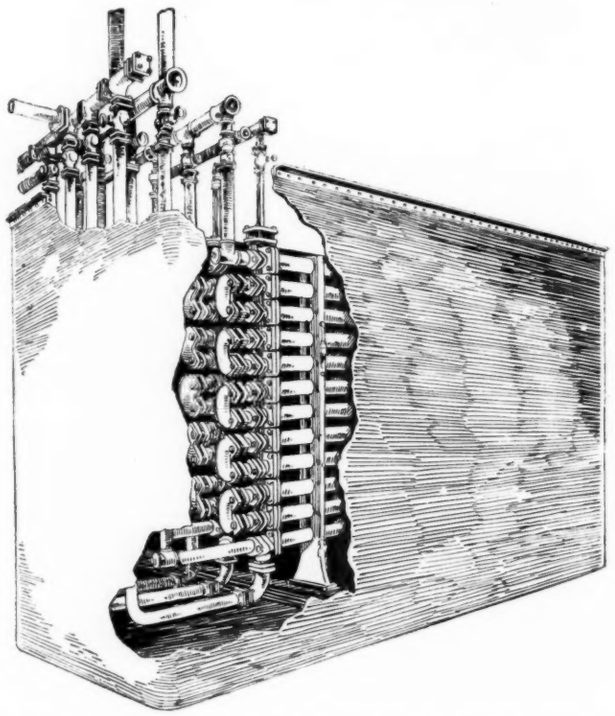


FIG. 3. LOOKING INTO A DOUBLE-PIPE BRINE COOLER

wear and tear to machinery, more shutdowns and more of everything in general except output of the plant; and all go to increase operating costs.

If the condensing pressure is running too high and the condensers are clean and a normal supply of water is given with no undue rise in temperature, the engineer should proceed to take the temperature of the water leaving the condenser. By adding eight or ten degrees and consulting tables on properties of saturated ammonia, the condensing pressure corresponding to the temperature can be found, and if the condensing pressure is found to be much higher than shown in the tables, it is a good indication that the condensers need purging. For example, assume that the temperature of the water leaving the condenser was found to be 88 deg. F.; adding 10 deg. gives 98 deg. F. and the corresponding pressure due to this temperature would be, as taken from the tables, 191 lb. If the condensing pressure is running much higher than this, it is evident that the condensers need purging.

In condensers of the Block, York, Ball and other types the efficiency and capacity depend on a supply of

liquid being carried in the condenser, and a shortage of ammonia will cause high condensing pressure. Without an ample supply of liquid part of the condensing medium is removed, and the hot gas coming in contact or mixing with the cooler liquid in the condenser has the same effect as the *jet* steam condenser where the condensing water is injected directly into the exhaust steam.

The suction pressure should be carried as high as the temperature conditions will permit, as the capacity of the machine depends mainly on the suction pressure or number of pounds of gas delivered to the condenser, returned and re-evaporated in the evaporating coils. One cubic foot of gas at 30 lb. will weigh twice as much as one cubic foot at 15 lb., and omitting the heat of compression, 30 lb. suction pressure will produce twice as much refrigeration as 15 lb.; provided, however, the boiling point of the liquid is low enough to do the work required.

Oil Separator on Discharge Line

As an extra precaution against oil and other deposits being carried over into the ammonia condenser, an oil or ordinary high-pressure steam separator, with a guaranteed working pressure of 300 lb. per sq.in., should be placed in the discharge line between the compressor and the condenser, and a 1-in. line led from it to a trap located below the separator, preferably in the engine room. The trap can be made of extra-heavy pipe with a ratio of about 10 cu.in. volume per ton of refrigeration.

Relative Value of Top and Bottom Feed of Ammonia to Evaporating Coils

The writer changed, on request, one 350-ton and one 150-ton brine tank from bottom feed to top feed. The evaporating coils in the brine tanks in question would evaporate enough ammonia with the bottom feed to maintain a suction pressure ranging from 18 to 25 lb., depending on the temperature of the brine, and this, too, with the machines running to the limit of their speed. The headers were changed in the spring of the year from bottom feed to top feed. Be assured it was a trying job to pull that plant through the following summer.

The best that could be had from the tank coils was an evaporation sufficient to carry a suction pressure on the machines of from 10 to 16 lb. and the machines not running up to the limit. There was loss in capacity of from 25 to 40 per cent. The first cool spell that coming fall all hands were put into the tanks to change the headers back to the bottom feed, with the result that the suction pressure could be carried at from 15 to 25 lb. with no trouble.

Now the question arises: Why this marked difference between the bottom and top feed? With bottom feed the coils will fill up completely with liquid, and as the whole external surface of the coil is in direct contact with the heated brine, the liquid will rise to a point where the saturated gas that is being evaporated and driven ahead of it will reach the top header at a temperature sufficiently low to frost the suction line leading to the compressor. When this point is reached, the coils will be filled to their working level and should be regulated the same as feeding water into a boiler, as before explained. The liquid completely covering the inside surface of the pipe and being surrounded by the heated brine on the outside causes violent boiling of the liquid which sets up or forces a fast circulation and rapid evaporation of the liquid ammonia; the principle is the same as that of the water-tube boiler.

The "top-feed" is where the liquid enters the top coil and gravitates downward to the bottom outlet, the heat being applied by the surrounding brine the same as with bottom feed. But in this case the results are somewhat reversed, as the coils are only *partly* filled with liquid ammonia, and instead of transferring heat from the brine to the liquid, it is being transferred to a small portion of the liquid and a large portion of saturated gas which is being superheated as it is forced downward to the outlet end of the coil. For example, consider a water-tube boiler with the inner surface of the tubes only partly filled with water and you have a a good illustration of a "top-feed" brine coil or brine cooler.

Operation and Adjustment of Turbine Machinery—VI
Shaft Packing

By Eustis H. Thompson
Consulting Engineer, Baltimore, Maryland

Shaft packing should not require adjustment at frequent intervals. It is, however, often difficult to dismantle, adjust and assemble. This packing has been perfected so that trouble is seldom experienced, but as troubles may be expected, their characteristics and causes are listed here. This list refers to high-pressure packing primarily, but what is true of it is true, to a large extent, of inter-stage and exhaust packing.

1. Leakage resulting in steam coming out of the casing, or lowering of vacuum. Causes: (a) Wear of packing rings; (b) weakened springs; (c) broken packing resulting from assembling or from vibration (the latter sometimes causes the packing to become jammed and broken; packing is also sometimes broken by moving the rotor in an improper manner while adjusting); (d) water coming through with steam; (e) bad alignment of the nozzle, which builds up pressure and vibration; (f) sprung shaft; (g) shaft running out of true due to unbalanced rotor; (h) back pressure in the drain due to back pressure of the sewer or to wind blowing into packing drain pipe.

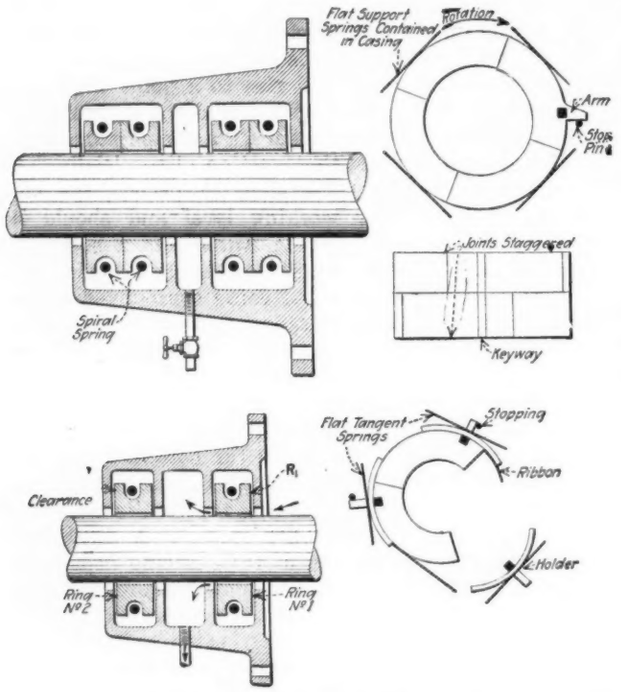
2. Cutting of shaft. Causes: (a) Rings fitted too small; (b) rings becoming jammed in the holders; (c) spring in shaft; (d) unbalanced rotor.

3. Heating of shaft. Causes: Packing rings fitted too tight.

4. Vibration. Causes: (a) Rings fitted too small for the shaft, especially in large machines and in inter-stage packing rings; (b) rings jammed in the holders on account of dirt and sediment from the steam; (c) rings slipping out of place from moving the rotor or from violent and sudden vibration.

5. Rubbing noise. Causes: Usually caused by metallic rings becoming jammed or slipping out of place so as to touch shaft.

Packing troubles in small machines cause heating more than vibration, but in larger units vibration usually occurs before heating. Sometimes a sudden period of vibration will occur several hours after refitting of the packing; with some types of packing rings it is easy for them to be displaced temporarily. When they work back into place, the ring may be a trifle too small, producing vibration. Unless vibration or heating seems to be serious, it is usually good practice to keep the machine running until the packing has worn large enough to free the shaft.



STEAM TURBINE PACKING

Upper Left—Carbon ring shaft packing. Upper Right—Flat support spring for the carbon packing rings; below are rings with staggered joints. Lower Left—One ring instead of two in a compartment. Lower Right—Another way of supporting a carbon packing ring.

Types of Packing

The most familiar type of shaft packing is made of carbon rings, and there are many ways of holding them in place. The method most employed is shown, upper left, which represents the garter-spring type. This ring is made of three or four segments held in circular shape by means of spiral springs stretched around it. The ring is supported by flat springs which allow it to move around in accordance with the position of the packing casing in relation to the shaft, so that it can take its proper position after expansion or contraction has changed the position of the casing. See the illustration.

Two rings are used together in a single compartment, as shown above. The joints of the rings are staggered. To keep the ring from turning, there is an arm keyed to it as shown. This contacts with a pin which is fastened in a carbon casing. The pin therefore holds the arm and prevents the ring from turning in the direction of rotation. The keyway also holds the rings in the staggered position so that the joints of both rings cannot come together while the key is in place.

This packing is varied by using one ring instead of two in a single compartment, as shown, the flat support springs not being used. The assembled packing illustrated is for the exhaust end of a non-condensing turbine. A little steam leaks around ring No. 1, and there encounters the drain by which it is much easier to reach atmosphere than through ring No. 2. This combination is about the easiest to adjust satisfactorily.

At the lower left a carbon ring is supported differently. Instead of using garter springs together with flat supporting springs, this ring uses flat springs tangent to the ring at several places. The springs at the bottom of the ring support the weight in addition to holding the spring in its circular form and are therefore usually a little stronger than the upper springs. It will be seen that the packing is free to move with expansion of the turbine casing.

Two kinds of joints—the butt joint for interior rings, and the lap for the outside ring—are used. In this position there is little steam pressure, and in such a case the joints are not arch-bound, therefore the ring is allowed to bear against the shaft all the way around. Copper ribbons are generally used over each joint. The clearance in each joint is usually about $\frac{3}{16}$ in.

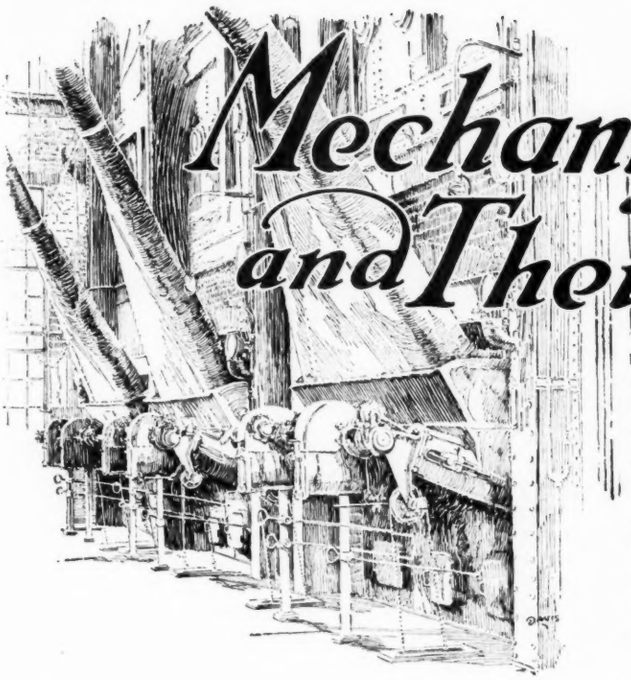
Carbon rings do not always have their weight supported, as the garter-spring types are sometimes used without supporting springs. All types of rings must have some arrangement to keep them from turning with the shaft.

Metallic packing rings are frequently used. Rings of this character are usually made with saw teeth so that they will wear when in contact with the shaft. Saw-tooth rings are sometimes known as labyrinth-type packing on account of the broken path of the steam when leaking past the ring. These rings are often provided with a collar which prevents them moving too near the shaft. They may be held in place by any combination of springs previously described. This type of packing is used between stages of the impulse turbine.

The stuffing-box type of packing is used mainly on small machines of impulse type. The material of this packing usually consists of babbitt metal or other soft anti-friction alloy stranded, and sometimes mixed with asbestos. In some machines rings of soft fiber packing are placed between the metallic rings.

Another type of packing is known as water-seal packing. This consists of two rings of carbon or metal as indicated, with water supplied between them. Provision is made for draining the water to keep it in constant circulation. This method is used in sealing against a vacuum and also in holding low-pressure exhaust steam. The circulating water condenses the steam that leaks past the inner ring and also tends to keep the rings and shaft cool.

A well-known type of water packing is constituted as described; there goes with it a small centrifugal pump placed on the shaft of the turbine. This pump throws the water in a fine spray against the packing rings, thus generating a pressure due to the velocity of the water, which is effective in sealing against exhaust steam or a vacuum.



Mechanical Stokers and Their Operation

Dealing with the classification of the principal types of mechanical stokers and their general application to boiler service. General instruction is given regarding the operation of each type of stoker and the method of banking and bringing the stoker into service again; also data regarding the draft of each type of stoker required at different rates of combustion.

UNTIL recently mechanical stokers were practically limited to handling bituminous coal. Anthracite is difficult to burn successfully on the average design of stoker, but a mixture of half anthracite and half bituminous coal can be burned with more or less success, and as a matter of fact many stoker operators have been obliged to use such a mixture during the last year, owing to their inability to secure a sufficient supply of soft coal.

The advantages of stokers are the adaptability of burning the cheaper grades of fuel; a saving of labor in plants over, say, 500 hp. capacity when provided with coal and ash-handling machinery; economy in combustion, with proper management especially when forcing the fires; uniformity of furnace conditions, the fires being maintained at an even thickness and being cleaned of ash either continuously or intermittently, depending upon the design. These features have an influence toward prolonging the life of the boiler.

A certain amount of skill is required on the part of the operator in handling stokers, otherwise the fires may become filled with holes, which will allow excess air to enter the furnace, and there may also be considerable loss of fuel in the ashes. Control of the air supply is an important item in the successful operation of stokers, but in every installation, if the best firing practice is to be had, the engineer in charge will have to work out the right amount of air, the depth of fire to be carried and the rate of feed.

Stokers can be classified under three general types—traveling grates, overfeed and underfeed. These three types are more or less familiar to steam users. The traveling or chain-grate stoker, Fig. 1, consists of an endless chain composed of small bars passing over sprockets at the front and rear of the furnace. From a coal hopper fuel is fed onto the front end of the stoker by gravity and is ignited as it passes under the ignition arch and, owing to the movement of the grate, is carried toward the rear of the furnace as combustion takes place. If the stoker is properly operated, the combustion of the fuel has been completed by the time the fire reaches the back end of the grate, and the ashes and refuse are carried over the end into the ashpit. A water box, bridge wall, or similar arrangement at the rear end acts as a seal to prevent the admission of excess air at that point. Other designs are provided with hand-operated dampers by which the air supply is controlled. Some chain-grate stokers are slightly inclined toward the rear of the furnace and others are horizontally placed.

Most chain-grate stokers are operated with natural draft, although some are used with forced draft. An ignition arch is necessary in order to deflect the heat and ignite the coal as it comes from the hopper. A flat arch gives uniform ignition over the entire width of the grate surface. Although natural or forced draft can be used, certain coals are not adaptable for use with forced draft. On chain-grate stokers coking occurs at the entrance of the stoker, but as the ignition arch is comparatively long the air and volatile matter are effectively mixed. Clinker troubles are absent, except some along the side walls, as the grates are automatically cleaned of ashes.

As this type of stoker has a large area, it can be forced to an average of 250 per cent of the boiler rating with a fuel combustion rate of around 48 lb. per square foot of grate area per hour, when burning coal that is suitable for the type. There is a probability, however, that at this rate of combustion the grate would become overheated when burning low-ash coal. The result would be high maintenance cost.

For efficient operation the draft must be under control and the damper operated between the closed and open position and the stoker not operated with the damper either wide open or entirely closed. Furthermore, the stoker should be so handled that no unconsumed fuel will be carried over the end of the grate; this can be avoided by regulating the thickness of the fire and by the damper adjustment. The variation of the fuel bed is governed by the load carried and by the fineness of the coal and its volatile properties. Experience has shown that it is better to run a thick fire slowly rather than a thin fire rapidly. An average speed for the chain-grate stoker is about 3½ in. per min. If

the live coal feeds over the end of the grate into the ashpit, the fuel is being fed either too fast or too thick or not enough draft is being supplied. For ideal operating conditions the fuel should be consumed upon reaching the rear end of the stoker, but the back end of the grate should never be allowed to become bare. The speed of the stoker should be such that the volatile of the coal will have been driven off before the coal has traveled one-half of the grate length.

When forcing fires with the chain-grate type of stoker, the damper should be placed wide open, the feed

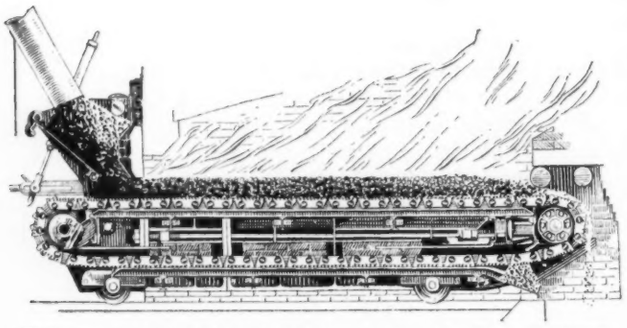


FIG. 1. CHAIN-GRATE TYPE OF MECHANICAL STOKER

gate lowered, the grate travel speeded up and the coal loosened up. This can be done by the use of a suitable flat-end bar by running it through the furnace, turning it over and pulling it out without disturbing the surface of the fuel bed, repeating the operation until the entire surface has been gone over. Using a slice bar to break up a fire will cause smoke, and although there is no plant that will operate smokelessly under any and all conditions of service, the degree of smoke formed depends largely upon the ability of the men handling the stoker.

Chain-grate stokers are practically adapted to Middle Western coals which run around 22 to 25 per cent of ash. Coals containing as low as 10 per cent ash can also be burned upon them. High-ash coals will require a draft as high as 0.6 in. over the fine and about 1 in. at the damper when burning 40 lb. or more of coal per square foot of grate surface per hour with an average depth of 5½ in. of fuel on the grate. Burning the same amount of coal, but of lower ash content, a draft of about 0.4 in. will do. When using forced draft, the air pressure over the fires may vary from atmospheric to 0.15 in. of water with a varying pressure in the wind box of 1 in. to 4 in. of water. For average results a minimum of 0.25 in. draft in the furnace should be available.

One method of approximately figuring the desired draft is to assume that about 10 lb. of coal can be burned per square foot of grate surface for each 0.1 in. draft in the furnace. Thus with a draft of 0.4 in. 40 lb. of coal could be burned per square inch of grate surface, and as high as 60 lb. of coal with an 0.6 in. draft. From 200 to 250 per cent rating and even higher can be obtained with this design of stoker, with natural draft.

Overfeed stokers are divided into two general classes. In one the coal is fed into the hopper at the front end of the furnace to the upper part of the grate, which inclines downward at an angle of about 45 deg. toward the rear of the furnace, Fig. 2. As the grates are reciprocating, taking alternate straight and inclined positions, the motion gradually works the burning coal to the bottom of the grate. Combustion is completed on a dump plate at the bottom; this plate also provides a means for dumping the accumulation of ashes and clinker. As the coal is coked on the upper end of the grate, the volatile gases are driven off and are ignited and burned in their passage over the bed of burning fuel on the lower portion of the grate.

The other design of overfeed stoker, Fig. 3, provides for the coal being fed from the side for the full length of the stoker and at the top end of the grate, which inclines toward the center of the furnace. These grates are given motion by means of rocking bars and the fuel is gradually carried to the bottom end of the grate, where a grinder reduces the clinker and deposits it into an ashpit.

These stokers are adaptable for burning either coking or free-burning coal, the latter because the movement of the grate keeps the fuel broken up, which prevents it from coking. Under ordinary operation a draft of 0.25 in. of water is required with natural draft; the maximum draft is about 0.6 in. About 50 lb. of free-burning coal per square foot of grate surface per hour is the maximum consumption and a maximum of 35 lb. per square foot of grate surface per hour when burning high-carbon coking coal can be obtained. Economical operation of from 150 to 200 per cent of rating can be easily carried and higher ratings have been obtained.

When the stoker is equipped with a dumping plate, the clinker and ashes collect on it and when a sufficient

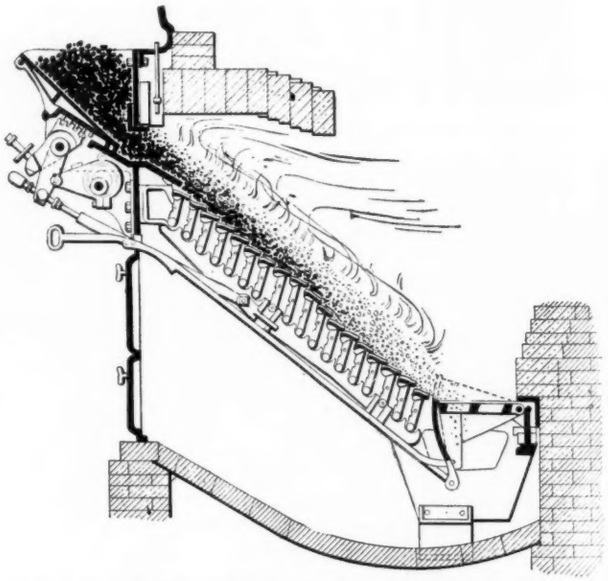


FIG. 2. FRONT-FEED OVERFEED TYPE OF STOKER

amount has been accumulated, it is dumped into the ashpit. Trouble is frequently experienced with clinker when burning some grades of coal. The larger pieces have to be broken up in order to pass the dump plate into the ashpit. Too frequently, the operator will attempt to break up the clinker by slamming the dump plate. This is poor practice as it causes live coal to fall into the ashpit. If the fireman is careless in doing this work, considerable burning fuel will be deposited with the ashes and wasted. A careful fireman can greatly reduce this loss. The longer the dumping process requires, the greater will be the heat loss due to the

inrush of cold air in the furnace while the push-hole door is open.

When the crusher, which forms the central part of the furnace, is used, the clinker is automatically taken care of, as it grinds it up and deposits it in the ashpit. The clinker is softened by blowing steam between it and the grinder and between the grates at the lower end. This steam is supplied from the exhaust of the stoker engine.

Fusing of clinker to the side walls and bridge wall is one of the troubles experienced with overfeed stokers if the fires are neglected. This can largely be prevented by slicing the fires and dumping the ashes before they become fused. The dumping interval will be determined by the grade of coal being burned and by experience. If dumping is done at too short intervals, the combustible will not all be burned, whereas if too long periods are allowed between dumpings, although the fuel will all be burned, there is the probability of clinker formation. As with any other type of stoker, or hand-fired grate for that matter, the grate must be covered with fuel, the thickness depending upon the load. This will prevent the admission of excess air as will occur with an uneven fire.

Poking the fuel of either front- or side-feed overfeed stokers generally tends to cause the burning fuel to slide down much faster than it would, due to the natural

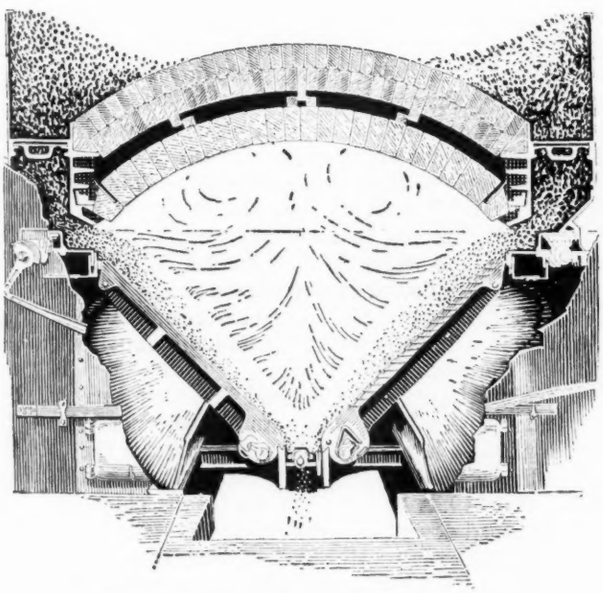


FIG. 3. SIDE-FEED OVERFEED STOKER

movement of the stoker grate, and this will necessitate the feeding of new fuel on the upper end of the grate in order to cover the base surface.

Fire Thicknesses Depend on Kind of Coal

Fire thicknesses are to be governed largely by the kind of coal burned, but a fire about three or four inches thick will give good results under ordinary circumstances. The fire should be kept even, and in the case of a side-feed stoker, if there is a tendency for one side to build up thicker than the other, the feed on that side can be reduced, or the thin side can be built up by means of a socket wrench.

If, in cleaning fires, all the clinker will not drop, it must be broken up with a bar and pulled out with a hook. If a crusher is used, its speed depends on the kind of coal used and its clinkering properties. When banking the fire of a side-feed overfeed stoker, remove all clinkers and pull the coke to the front end of the grate and then cover the live coals with fresh fuel. All doors should then be closed and the damper left open just enough to allow the gases to escape up the chimney. Of course the fuel magazine should be empty. When starting up from a banked fire, the live coals should be

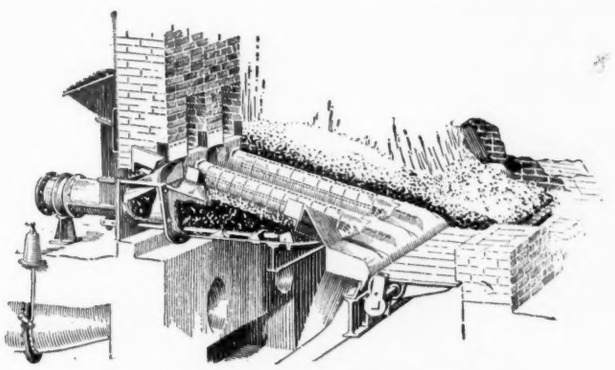


FIG. 4. UNDERFEED TYPE OF STOKER

spread along the bottom of the grate and covered with coal from the magazine and then the draft doors and dampers should be opened.

Stokers equipped with fuel magazines require that they be kept evenly filled with coal so that an even distribution of fuel will be had. Always so gage the fuel supply that when shutting down the stoker there will be no coal in the hopper and the fire will have been burned out; otherwise it will be necessary to empty the magazine to prevent the coal from catching fire.

These stokers are adaptable for variable loads because they may be operated with reduced grate area by allowing the bottom of the grate to fill partly with ashes. Ashes should not be allowed to collect in the ashpit, as this will cause burned grates. The distance from the grate may be from 5 to about 9 feet.

Underfeed stokers have been in use for years, and many of the largest installations are of this type. They have the advantage in that the tuyeres are covered with green or partly coked coal, which tends to protect the grate. Practically the entire furnace area is utilized to distill volatile matter, and all the air supplied to the furnace is thoroughly mixed with the volatile gases before it has escaped from the fuel bed. Another favorable condition is that the combustible gases pass through the hottest fire zone before reaching the furnace. Furthermore, no arches are required as with most other types of stokers, thus saving considerable in first cost and in upkeep.

Three Hundred Per Cent of Rating Maintained

Underfeed stokers can be forced up to 300 per cent of rating, which rate can be maintained continuously, and burn from 60 to 65 lb. of coal per square foot of grate surface. As to the stoker's efficiency in general, the best is obtained when the boiler is operated at not less than 100 per cent of rating.

With underfeed stokers the coal is pushed forward and upward by a ram or rams, so that the fire is always on top. The fresh coal is pushed forward and upward

and is gradually heated and coked. The volatile is driven out during the coking process and mixed with the air that is admitted through the tuyere opening. Forced draft is used, the air supply being controlled by a damper. Coal is fed into a hopper on the outside of the furnace and falls by gravity to the front end of the plunger retort and is then pushed into the furnace.

Underfeed stokers are made in two designs. In one the coal is pushed into a central part and is then fed over the grate area on both sides of it, Fig. 4. After the proper adjustments have been made the coal is fed automatically and each stoker can be operated independently. Such stokers may be cut out of service and banked while light loads prevail and held in readiness to be put back into service. To maintain a banked fire

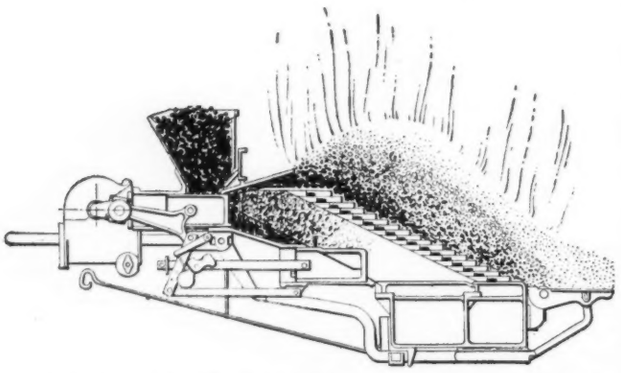


FIG. 5. UNDERFEED GRAVITY-FEED TYPE OF STOKER

for several days, it is only necessary to feed additional coal occasionally, keeping the dampers closed. To start from a banked fire, remove the ashes, open the damper and air grates, and then start the stoker. With this design of stokers no slicing or poking of the fire is necessary as the stoker takes care of the breaking up of the fuel bed.

As with any other kind of stoker, the proper supply of coal and air is of the greatest importance and the relation of available draft to the amount of coal to be consumed must be studied by the men in the boiler room. As about 8 lb. of coal can be fed at each stroke of the ram and as the stroke of the ram may be regulated from one to about eight per minute, the amount of coal necessary to be burned for a given load can be easily regulated. A draft of 2 in. will generally supply sufficient air to take care of four strokes per minute, which would be feeding 32 lb. of coal. This would permit of all combustibles being burned by the time the coal reached the dump plate, when one is used.

Live coal should be prevented from accumulating on the dump plate as such accumulations tend to increase the temperature and result in the fusing of the ashes into a clinker which is difficult to dump. Attempts to dump large clinkers by working the dump plate will cause the loss of good fuel by its being dumped into the ashpit. When large clinkers form on the dump plate together with combustibles, close the ashpit door and open the grids in the air box, if so constructed, thus putting the dump plate under forced draft. The stoker should be stopped at the same time until the fuel on the dump plate has become at least partly consumed, closing the grids again as soon as possible.

Fire about 10 to 12 in. thick is usually carried and the cleaning of the ash and clinker should in general be at least once in every two hours. If the furnace is being run lightly, unburned coal may be worked onto the dump plate, in which case it should be winged back with a suitable bar.

The Gravity Underfeed Stoker

The other design of underfeed stoker is known as the gravity feed, Fig. 5, and is used extensively in Eastern power plants. The several makes are similar in many respects. Coal is fed into the hopper by various means and rams force it into the furnace, which controls a sloping grate and the refuse moves automatically toward the bottom as the combustible is consumed. As the coal leaves the plunger, it begins to coke and then moves farther into the furnace, where it is consumed.

When starting a gravity underfeed stoker, care should be taken not to carry a fire too heavy or too hot on the ash plate, which can be protected from the furnace heat by covering with ashes. After the stoker is in operation, the ash plate should not be kept open any wider than necessary to just allow the ashes to fall through, and it is best to keep it closed sufficiently to maintain a layer of ashes over the opening and a fixed bed of ashes over the plates so as to protect them.

Sometimes it becomes necessary to dump hot clinkers and refuse into the ashpit, in which case they should be cooled by playing a stream of water over them after dumping. No water, however, should reach any part of the furnace. Very large clinkers may be dumped by withdrawing the ash-support plate in order to let the clinker drop through.

The fires are banked as with other types of stokers. First shut off the air supply and push in coal until the required depth of the bank is obtained. This depth will depend on the length of time the stoker is to remain idle. It is best not to allow very much, if any travel of the side bars when the fires are banked, and the fire should not be allowed to burn down to the tuyere plate or air box, as when the air box becomes cracked fuel will fall into it and become ignited, which will further damage the box.

When starting from a banked fire, first turn on the air and then start the side bars at their normal travel and run the stoker with the hopper empty if the banked fire is heavy, thus preventing feeding of fresh coal until the bank bed has been broken up by the side bars and it has burned down to normal thickness.

Underfeed gravity stokers are adaptable to burning bituminous, semi-bituminous and semi-anthracite coal. Forced draft is used, and for normal rating 1.5 to 2 in. pressure in the wind box is about what is required with a 0.03 in. suction in the furnace. Maximum loads require from 3 to 6 in. pressure in the wind box and 0.05 in. suction in the furnace. Long-continued loads of from 250 to 300 per cent of ratings can be maintained and even daily peaks of 400 per cent can be carried. Under normal rate of combustion 40 lb. of fuel can be burned per square foot of grate area per hour and from 60 to 80 lb. of fuel can be burned during short peaks of, say, two to three hours.

Overspeeding fans for the purpose of increasing the volume is not practicable, as this will rapidly increase the power consumption. Fans are designed to deliver a certain number of cubic feet of air at a certain pressure when running at a certain speed. Any diversion

from the stipulated speed will, of course, produce a different delivery curve, pressure curve and power-consumption curve. For instance, by doubling the speed, twice the amount of air will be handled with four times greater pressure than before, but with an expenditure of eight times as much power for driving the fan.

In conclusion, the life of stokers, blower equipment, etc., depends upon the usage they receive. With proper care a stoker should be serviceable for at least fifteen years. If it is neglected or abused, its life is reduced and the maintenance charge will be higher than it should be. A stoker cannot be expected to give satisfactory results if given no attention other than filling the hopper with coal. Ignorance and careless handling have ruined many a stoker.

Multipliers for Use with Portable Voltmeters and Wattmeters

By H. C. Yeaton

When it is required to use a voltmeter to measure the voltage of a circuit which is in excess of the instrument's rating, an external multiplier may be used and connected in series, as shown in Fig. 1. When a multiplier is used with a voltmeter, the readings have to be multiplied by a constant. This constant K can be determined from the formula,

$$K = \frac{R_i + R_m}{R_i},$$

Where R_i equals the resistance of the voltmeter and R_m the resistance of the multiplier.

When a multiplier is made to be used with a particular instrument, the resistance in the multiplier is so calculated and adjusted that the multiplying constant is an even number. Suppose that a voltmeter has a scale of 150 volts, the resistance being 1,800 ohms, and it is desired to have a multiplier with a ratio of 2:1, so as to adapt the voltmeter for use on a 300-volt circuit. The resistance of the multiplier is $R_m = (KR_i) - R_i$. By substituting in the formula, the required resistance is obtained; that is, $R_m = (2 \times 1{,}800) - 1{,}800 = 1{,}800$ ohms.

If it is required to use a voltmeter on a circuit in excess of its voltage rating and a multiplier with an even constant is not available, any multiplier can be used provided it will withstand the watts load to which it will be subjected and the resistance is sufficient. Suppose that a voltmeter has a scale of 150 volts, the resistance of the voltmeter being 2,800 ohms, and the multiplier available happens to have a resistance of 3,300 ohms. The value of constant K by which the voltmeter readings will have to be multiplied by, is

$$K = (2{,}800 + 3{,}300) \div 2{,}800 = 2.18$$

Therefore the readings of the voltmeter would have to be multiplied by 2.18 to obtain the correct voltage of the circuit being measured.

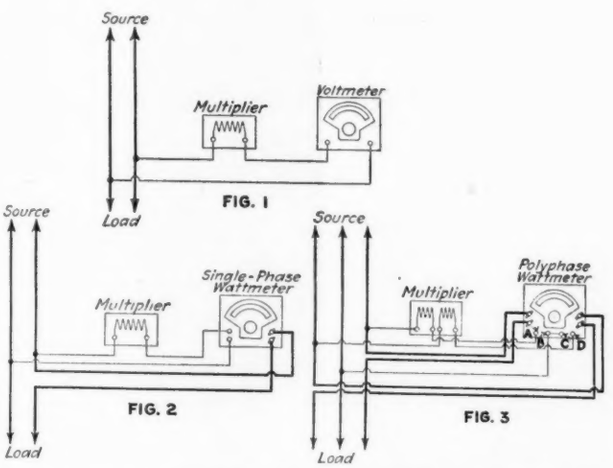
As a single-phase wattmeter has only one potential element, the same procedure may be followed for determining the resistance or constant of a multiplier, as that explained in the foregoing, covering voltmeters. Fig. 2 shows the connections of a single-phase wattmeter used with a multiplier.

A polyphase wattmeter has two potential elements, therefore it is necessary to connect a multiplier in each potential circuit, as in Fig. 3, when the meter is to be used on a circuit in excess of its rated voltage. Each multiplier will have a constant, and the average of both constants will be the constant that should be used to multiply the readings by, in order to obtain correct results.

If a multiplier was to be made for use with the polyphase wattmeter, the former's resistance would be so calculated and adjusted that the multiplying constant would be an even number. Suppose that a polyphase wattmeter had a voltage rating of 150 volts and it was desired to have a multiplier with a ratio of 2:1, so as to adapt the meter for use on a 300-volt circuit. In Fig. 3 assume that the resistance of the potential circuit AB is 2,000 ohms and the resistance of the other potential circuit CD is 2,100 ohms.

The resistance to be used in series with potential circuit AB is $R_m = (2 \times 2{,}000) - 2{,}000 = 2{,}000$ ohms, and that in CD is $R_m = (2 \times 2{,}100) - 2{,}100 = 2{,}100$ ohms.

If it is required to use a polyphase wattmeter on a circuit on which the voltage is in excess of that of the



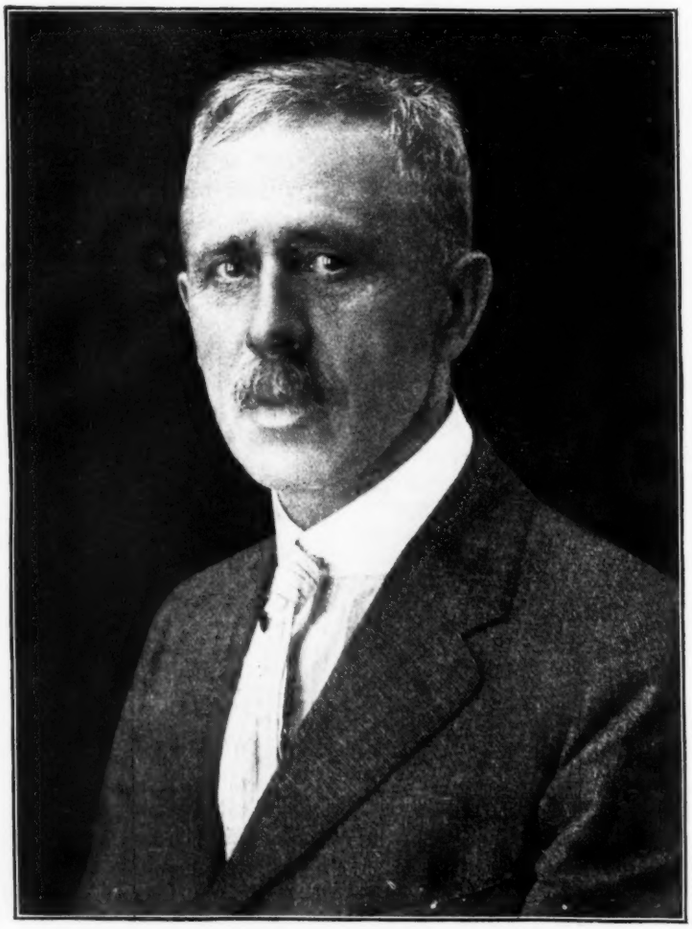
FIGS. 1 TO 3. CONNECTIONS FOR USING A MULTIPLIER WITH VOLTMETERS AND WATTMETERS

meter's rating, and a multiplier with an even constant is not available, any multipliers may be used, providing that the resistance in the multipliers is sufficient to meet the particular requirements and they will not heat excessively. It is advisable to use resistances of approximately the same values in series with each potential element, so that the elements of the wattmeter will be nearly balanced.

Suppose that a portable polyphase wattmeter has a voltage rating of 150 volts and the resistance of the potential circuit AB, Fig. 3, is 2,000 ohms and that of CD is 2,100 ohms. It will be assumed that the multiplier available for AB is 2,300 ohms and the resistance of that available CD is 2,000 ohms. It is required to use the wattmeter on a 300-volt three-wire three-phase circuit. The constant for AB potential circuit is $K = (2{,}000 + 2{,}300) \div 2{,}000 = 2.15$, and for the CD potential circuit is $K = (2{,}100 + 2{,}000) \div 2{,}100 = 1.95$. Averaging these constants gives $(2.15 + 1.95) \div 2 = 2.05$. Therefore the readings of the polyphase meter would have to be multiplied by the constant 2.05 to obtain the correct results of the circuit being measured.

Charles W. Naylor

ROUNDING out his thirty-fourth year in the service of Marshall Field & Company, the subject of this sketch gives a striking example of loyalty. He has had many opportunities to better himself financially by engaging in other work, but his heart has been with the firm that he, and his father before him, have served for so many years. No engineer in Chicago is more popular. The firm appreciates his rigid attention to duty and the efficient supervision of the work under his charge. His associates like his human qualities, and his fellow engineers from coast to coast recognize his ability. Charles William Naylor hails from old Albion. He was born at Leeds, England, Oct. 29, 1858. His father, William Naylor, was a locomotive engineer on the railways in the Manchester district. To get away from railway work, which was distasteful to the new bride, the family took passage for America when Charlie was eleven months old. The trip from Liverpool to New Orleans, in a combination steam and sailing vessel, took five weeks, so that young Naylor had his first birthday anniversary on the ocean and in Southern waters. Up the Mississippi River the journey was pursued to Southern Illinois, the family settling at Mt. Carmel, now the center of the vast Illinois coal and oil fields, but coal and oil were far from the dreams of the people thereabouts at that time. Immediately after the Civil War the family moved to western Missouri, later to Vincennes, Ind., and in 1868 to Chicago, then a prosperous city of 150,000 inhabitants. From that time on young Naylor received the benefits of excellent public schools, and he took full advantage of the opportunity. He was always studious and forward in his classes, graduating with honors from the Central High School at the age of seventeen.



CHARLES W. NAYLOR

At this period of his life Charlie was taken in hand by his father, who was proud of his ability and wished to give him all the advantages of a good education in his life work. His own words to his son best express his sentiments: "Boy, I am going to send you to college—you deserve it—but for fear you will be too proud to work after you get a degree, you are first going into the shop. I will place you with the Crane Company for two years." The dictates of his father were followed, and as Charlie had had previous experience in shop work during his summer vacations, he was a good mechanic at the end of the stipulated period. Much of his success in his subsequent engineering work he attributes to the experience and training gained at this time.

Entering the University of Chicago, he excelled in the sciences and mathematics, receiving the degree of B.S. in 1881. During his college days he became a member of the Greek letter fraternity, Psi Upsilon. After graduation he had the usual desire to see something of the world. Having gained a working knowledge of the transit, he went with the Illinois Central Railroad and finished out the year surveying through Tennessee and Mississippi. A dangerous swamp fever cut short his days of roving. He returned to Chicago and entered the employ of the Hay & Prentice Co., then the largest firm of steam-heating and ventilating engineers in the West. Not long after he was called to the position of first assistant engineer with the firm of Field & Leiter, now Marshall Field & Co., where he is chief engineer today and is just rounding out his thirty-fourth successful year with this great corporation. Throughout this period and particularly from his twelfth to his twenty-fifth year he burned the midnight oil, hungry for a knowledge of the arts. However, he was not unmindful of his health and physical well being. For ten years he was a frequenter of the gymnasium, taking a consistent and intelligent course of athletics. Though slight of build, he is something of an athlete and can do his distance and jump with the good ones to this day. On his college nine he played third base when such things as masks and gloves were unknown. For many years he was secretary of the Union Athletic Club, composed of active athletes, and officiated on numerous occasions at annual meets of the American Athletic Union. He is still fond of outdoor sports.

In 1890 he joined the National Association of Stationary Engineers and has been an ardent supporter of

this organization ever since. He was national president in 1893 and national secretary from 1897 to 1899. Charlie has attended twenty-five of its annual conventions, and when it comes to his local, No. 28 of Chicago, he seldom if ever misses a meeting. Here he has filled all official positions. For six years he has been a member of the association's national educational committee, part of his duties being to edit the first three volumes of its handbook, and he is now engaged on the fourth volume.

His efforts and his interest have not been limited to one organization, for he has been a member of the Western Society of Engineers since 1905 and a member of the American Society of Mechanical Engineers since 1895. Of the Chicago branch of the latter society he was a director for three years and for some time its secretary.

Since 1895, from October to April of each year, Naylor has lectured on steam engineering before the evening classes of the Y. M. C. A., being by seniority dean of the faculty. His success in this line is attested by hundreds who have attended his classes. He is a rapid, fluent talker, original in his methods of stating facts and positive in his convictions. He insists on his pupils getting the "idea of the thing." Keeping away from the orthodox methods of pedagogy, like Professor Perry, of London, he is looking for results and the men under him seldom forget a thing after it is explained in his "get-to-the-point" way.

For many years he was official marker for the advanced engineering examinations of the Chicago Civil Service Commission. During the late war he was one of the volunteers who served with the Fuel Administration in Illinois. He has always had an ingenious turn of mind and has originated and marketed numerous improvements in machinery, although he has never taken out a patent.

In the daily performance of his work Charlie dislikes red tape. He trains his subordinates to be rapid thinkers and self-reliant and for these very reasons holds the respect and esteem of the men who at one time or another have been in his service.

Annual Convention N. A. S. E. at Milwaukee

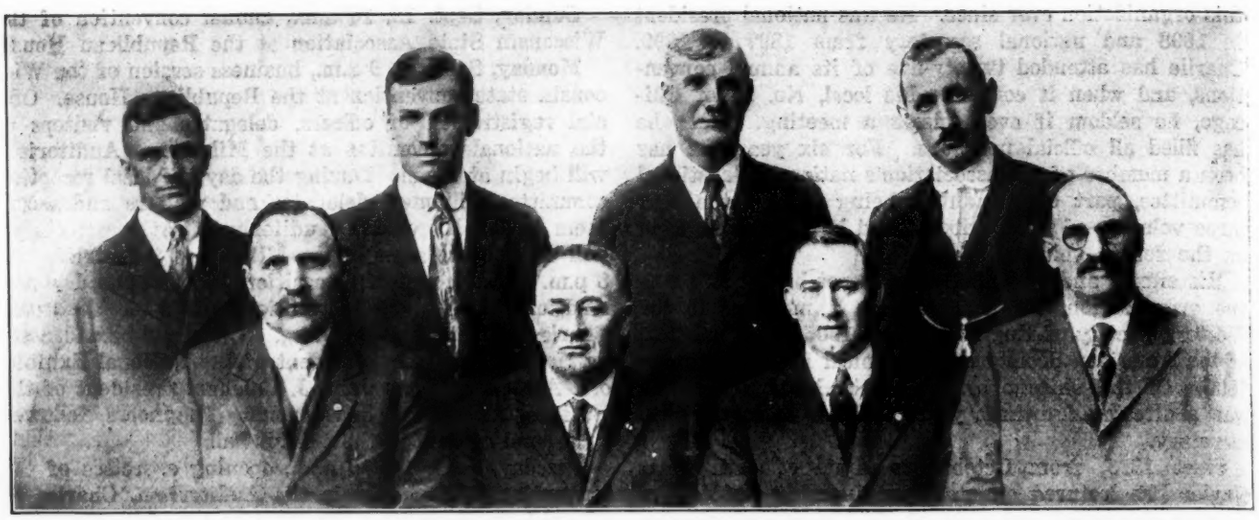
Prospects are bright that the thirty-eighth annual convention of the National Association of Stationary Engineers will be a record breaker. It is to be held in Milwaukee during the week of Sept. 13. Convention headquarters is to be at the Hotel Wisconsin, and the exhibits and business sessions will be held in the Auditorium, an ideal building for the occasion. Special committees have been appointed to handle each specific detail of the convention. There will be technical papers and welfare discussions, following the practice at recent conventions, and for the field-day exercises Washington Park will be at the disposal of the visitors. Baseball, horse races, boat races, outdoor sports and entertainment of every description are on the program given under the auspices of the Milwaukee Chamber of Commerce. In addition there will be inspection trips to industrial plants, the pulverized-coal installation of the Milwaukee Electric Railway and Light Co. and other points of interest. The indications are that Milwaukee will surpass all previous performances as a convention city. The program in detail follows:

Sunday, Sept. 12, 10 a.m., annual convention of the Wisconsin State Association at the Republican House.

Monday, Sept. 13, 9 a.m., business session of the Wisconsin state convention at the Republican House. Official registration of officers, delegates and visitors to the national convention at the Milwaukee Auditorium will begin at 9 a.m. During the day the local reception committee will meet delegates and visitors and escort them to the Milwaukee Auditorium. At 2 p.m. there will be visits to some of the Milwaukee industries. At 8 p.m. the Mechanical Exposition will be opened at the Auditorium with the convention committee chairman, Charles F. Bindrich, presiding. There will be addresses by Horace A. Smith, president of the National Exhibitors' Association, and John J. Calahan, president of the National Association of Stationary Engineers, followed by a band concert in the exhibit hall.

Tuesday, Sept. 14, 10 a.m., opening exercises of the convention will be held in the Auditorium, Charles F. Bindrich, presiding. There will be an address of welcome to the State of Wisconsin by Gov. E. L. Phillips, the response by National President John J. Calahan, an address of welcome to the City of Milwaukee by Mayor Daniel W. Hoan and addresses by National Vice-President Alfred Johnson, Phil A. Grau, general secretary of the Milwaukee Association of Commerce, and Past President Roderick McKay. At the end of the opening exercises National President John J. Calahan will announce the convention committees. The official photograph will be taken on adjournment. At 1:30 p.m. the first business session of the convention will be held in Juneau Hall, Auditorium, where all business sessions will convene. It will be devoted to the reports of officers and standing committees presented in abstract, a

HOTEL WISCONSIN, CONVENTION HEADQUARTERS



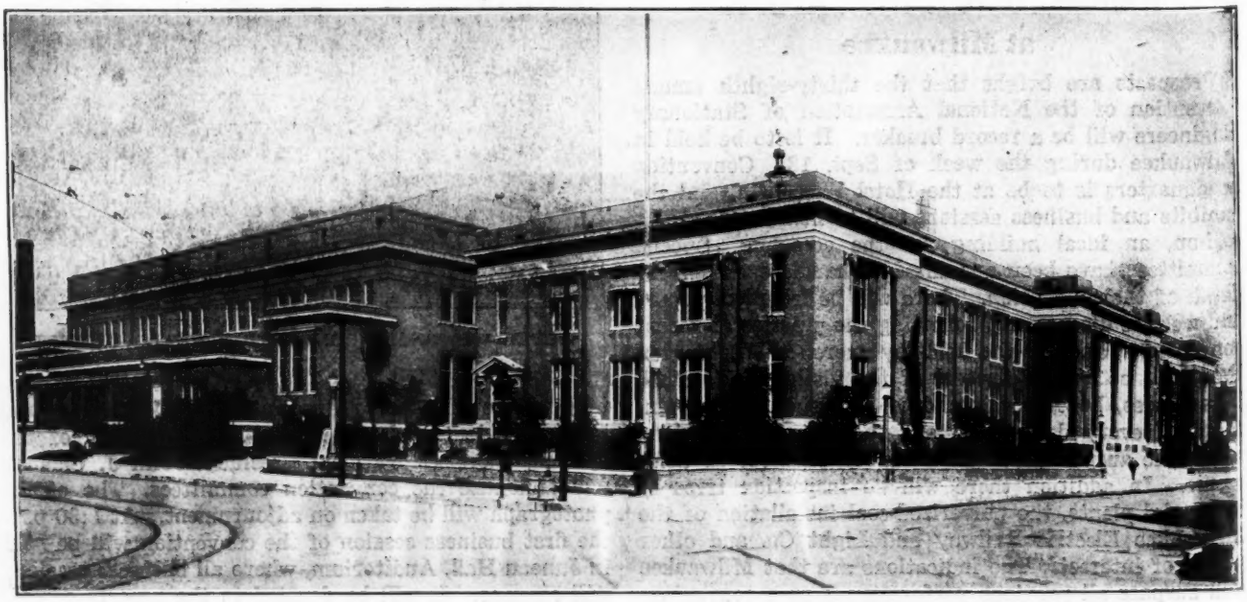
NATIONAL CONVENTION COMMITTEE, N. A. S. E.
Left to right: Seated—John A. Wickert, secretary; Charles F. Bindrich, chairman; Thomas W. Armer, Charles A. Cahill. Standing—Harry E. Fritz, H. A. Barr, Harry J. Mistle, J. A. Prudell.

lecture at 3 p.m. on "Science and Engineering," by Ben S. Elliott, professor of mechanical engineering, University of Wisconsin, and at 4 p.m. the annual meeting of the Life and Accident Department. After 4 p.m. there will be a visit to some Milwaukee industry and at 8.30 p.m. the exhibit hall will open. A very interesting program is being arranged.

Wednesday, Sept. 15, 9 a.m., business session for presentation of reports, official roll call of officers and delegates and routine business; 10:30 a.m., a lecture on "Importance of the Operating Engineer" by H. B. Wilder, of Detroit. At 11:30 a.m. there will be an address by a representative of the American Red Cross Association. The exhibit hall will remain open from 8:30 a.m. to 12 noon and from 7 p.m. to 10 p.m. The afternoon will be devoted to the field-day exercises, including baseball, horse races, boat races, running races, outdoor sports and entertainment of every description, at Washington Park, Milwaukee's most beautiful recreation spot, given under the auspices of the Milwaukee Association of Commerce. At 8 p.m. moving pictures of industries in Milwaukee will be presented at the Auditorium.

Thursday, Sept. 16, 9 a.m., business session, reports of convention committee; 10:30 a.m., lecture on "Thermometer and Pyrometer in the Power Plant," by W. J. Neely, of Chicago; 11:15 a.m., official visit to convention by the Ladies' National Auxiliary; 11:30 a.m., Memorial services; 1:30 p.m., business session, legislation committee reports; 3 p.m., topical discusion on "Capacity and Maintenance Costs" opened by Charles A. Cahill, consulting engineer, Milwaukee; 4:30 p.m., visit to some Milwaukee industry; 8 p.m., entertainment at the Auditorium by the National Exhibitors' Association. A special program is being prepared for the visiting ladies' comfort and pleasure.

Friday, Sept. 17, 9 a.m., business session, final committee reports, unfinished business, election of officers, election of the next place of meeting; 8 p.m., public installation of officers and annual ball at Auditorium.



THE AUDITORIUM, MILWAUKEE, WIS., WHERE ALL MEETINGS AND EXHIBITS WILL BE HELD

EDITORIALS

Convention of the National Association of Stationary Engineers

FOR the fourth time in its history the convention of the National Association of Stationary Engineers will be held in Milwaukee. The meeting next week will be the thirty-eighth annual convention of this body.

Both the business sessions and the mechanical exhibit promise to be among the largest in the life of the association. That there are approximately two-hundred and fifty booths at the exhibit, more than have appeared in any year since the outbreak of the Great War in Europe, is but one more of the many signs of the reorganization of business upon sounder economic lines than has been the rule in the troubled years of the recent past.

It is to be expected that high railroad passenger rates will keep at home many who otherwise would attend. But representation always is large. The technical papers sessions, started but a few years ago, have been more popular than many expected them to be. This year interest in these sessions promises to be greater than ever. A material increase in membership is one of the outstanding features of the year.

Has the Public a Right To Know What It Costs To Mine Its Coal?

A BIG principle is at stake.

Has the public a right to know how much it costs to produce the fuel upon which its existence depends and how much the producer realizes by its sale?

The Federal Trade Commission demanded this information for the public. The coal producers challenged the right of the Commission to demand it and procured an injunction by Mr. Justice Bailey of the Supreme Court of the District of Columbia restraining the Federal Trade Commission, "its members, agents, assistants, deputies and employees, from taking any steps or instituting or causing to be instituted any proceedings to enfore said order or to require the plaintiff to fill out and file the prescribed form of report."

Pending an appeal of this or a similar case to the United States Supreme Court, the Federal Trade Commission has issued reports based upon voluntary returns from a comparatively few operators. The summaries of the five monthly reports so far issued are as follows:

	Jan.	Feb.	Mar.	Apr.	May
Average Cost per ton f.o.b. at mines.....	$2.32	2.43	2.34	2.76	2.77
Average price per ton realized at mines..	2.74	2.74	2.76	3.26	3.31
Number of operators reporting.....	1,589	1,431	1,068	812	680

It will be noticed that the number of operators voluntarily reporting has fallen steadily away, and the Commission in its last report announces that unless a sufficient number of reports are received to make the figures representative it will discontinue the issue of the monthly report until its authority to collect the information is affirmed or denied by the Supreme Court.

The decision of the court will be watched for with keen interest by those who are awake to the import of the issue involved. The relation to the industries, institutions and homes of the country of those who have fastened upon and undertaken to exploit the natural fuel resources of the nation are different from those of a vender of molasses taffy. The people are willing to leave the winning and distribution of their fuel supply to private enterprise so long as they are satisfied that it is done with a fair degree of efficiency and at a reasonable profit, but they have a right to know how much it costs and how much the producer and middleman are taking from them for it. And the question is vital to everybody whether he ever buys a pound of coal or not, for the cost of fuel enters as an element into the cost of manufacture and distribution of everything that he does buy.

It will be a momentous decision—let us hope that it will be right.

Connections Between Brushes and Brush-Holders

SPARKLESS commutation of modern direct-current machinery has been obtained by a very extended series of refinements in design. These refinements have been not only in the machine itself, but also in the brushes. The introduction of interpoles and compensating windings and a better proportioning of parts have played an important rôle, as also have improvements in commutator construction, but the development of brushes on a scientific basis has contributed to satisfactory operation of direct-current machinery as much as or more than any other feature. Although the modern brush may not be all that might be desired under all conditions, nevertheless it does meet a majority of applications satisfactorily. Future investigation by the various manufacturers will no doubt result in improved characteristics.

No matter how well a brush may be suited to a given application, it will fail to give good service if not properly applied and maintained. One of the frequent causes of brush trouble is high resistance between the brush and holder, either from loose or from improper connections. In this issue Warren C. Kalb's article, "Connections Between Brushes and Brush-Holders," very carefully analyzes the necessities of such connections. It is a generally accepted theory that in a clamp type of holder all that is required is to keep the brush securely fastened to the holder. However, the surfaces in contact with the brush will corrode to a greater or less degree and cause a change of resistance, which in turn will produce an unequal distribution of current in the brushes. The heating that results from this unequal distribution may be sufficient to destroy the characteristics of the brushes carrying the excess current and cause sparking. With the pocket type of holder lack of or improper connections cause a current flow from holder to brush that disintegrates both, and produces excessive heating, which destroys not only the brush characteristics but also the tension springs. This not infrequently leads to difficulties that can be remedied only by a complete renewal of the brush-holders. From

Mr. Warren's analysis it is evident to those who have had experience with direct current that many of the chronic cases of brush trouble can be traced directly to improper connections between brushes and brush-holders, and that one of the most fruitful sources for maintaining satisfactory operation is to give careful consideration to the brush connections.

National Electric Safety Code Explanatory Edition

THERE have been promulgated in this country many different National codes of recommended practice in various branches of engineering. Representatives of these are the Boiler Code and Test Code of the American Society of Mechanical Engineers; Standardization Rules of the American Institute of Electrical Engineers; National Electrical Code of the National Board of Fire Underwriters; National Electrical Safety Code of the Buerau of Standards. The revised edition of the last-mentioned is to be issued some time during this year. No matter how carefully a code may be prepared, it is almost impossible to express the true meaning of every item in words alone. Proof of this is found in the application of some of the codes now in use. Not infrequently those who have to be guided in their work by the rulings misinterpret them or the inspector in one district will put upon a certain rule a different interpretation from that held by an inspector in another locality. Such practices lead to confusion, delays, unnecessary expense and dissatisfaction and are detrimental to the proper harmony among those who are to be guided by the code and those intrusted with its enforcement.

There have been published at various times interpretations of the different items in a number of these codes, which show by illustrations what the authors who formulated the rules had in mind and how they intended the regulations should be applied. This has generally been further elucidated by illustrations of examples of the best practice in applying the rules. Those who have availed themselves of these explanations appreciate their great value in properly interpreting and applying the regulations in their work. It has recently been announced that the Bureau of Standards, Washington, D. C., has under advisement the preparation of a pictorial edition of the National Electrical Safety Code, in which the meaning of the rules will be shown largely by illustration. The value of such an edition in applying this code can hardly be overestimated. There is probably nothing that could be done that would do more toward popularizing the use of the National Electrical Safety Code than the publication of this explanatory edition.

Price Relief Slow but Steady

THESE are times when everything costs a lot of money. Whether one goes to buy a center punch or a house, one is astounded at the price demanded. It was a little more than a year ago that President Stone, of the Brotherhood of Locomotive Engineers, in a letter to President Wilson, stated that his men did not ask for more wages, but urged immediate action to the end that the cost of living be lowered. Since then there have from time to time appeared reports and interviews that at last prices were coming down. Disappointment, not relief, usually followed. So many times has this happened that people have become suspicious or look for increases every time prices are reported as falling.

But a new situation has developed. Prices of raw materials are on the decline, and generally, the price curves will continue in that direction despite the increase in freight and passenger rates. High labor charges will, of course, continue as one of the great factors in keeping prices high. In this connection, however, it is of interest to note that last month immigration into the United States from Europe was higher than at any time since the war. This increase, if long continued, would doubtless affect the labor market, both skilled and unskilled.

Economic recovery from such a colossal upheaval as the Great War of necessity is slow. Reports from Europe show the several countries there to be steadily coming back to normal. America's recovery is probably the most rapid of all. The effect will be to lighten the cost burden in the power plant and to relieve the engineer-in-charge of the many additional worries he has been subjected to these three or more years. But relief will not come hurriedly, though it comes steadily.

Who Gets It?

THE average cost per ton of bituminous coal f.o.b. at the mines as voluntarily reported by some of the operators varied from $2.32 in January to $2.77 in May of this year.

The annual report of the Board of Public Works of Pawtucket, Rhode Island, gives the price per ton of coal used for its pumping stations during 1919 as from nine dollars to ten dollars and a half.

The Public Service Corporation of New Jersey, in petitioning for authority to increase the price of gas, urges as one of its reasons that it is obliged to pay fourteen dollars a ton for coal.

Mayor Creamer of Lynn testified before the Senate Investigation Committee that coal operators with whom the city had contracts at around nine dollars per ton could not fill their contracts at that price, but would sell them quantities of coal at sixteen dollars.

Admiral Benson, chairman of the Shipping Board, says that the board is paying from eighteen to twenty dollars a ton for bunker coal at Atlantic and Gulf ports.

You know how much you are and have been paying.

You know, or can easily find out, the freight rate from the mines to your plant.

Who is getting the difference?

And why are they allowed to continue to get it?

Almost all means for speeding up transportation and increasing the efficiency of transmission of intelligence have been utilized in the construction and operation of power systems. Wireless telegraphy and telephony have already found a place on some power systems for emergency transmission of messages. The latest acquisition to transportation in power-plant construction is the airplane, as is now being used by a construction engineer on one of the large systems on the Pacific coast. This is a beginning. How far can it be applied?

What is high speed for power machinery? Not so long ago it was a few hundred revolutions. However, with the introduction of high pressure steam and the steam turbine, there seems to be practically no limit except the rate at which steam will flow through an orifice. The speed at which some modern steam turbines operate would a few years ago have done justice to the vivid imagination of a mind like that of Jules Verne.

CORRESPONDENCE

Attention to Details

The engineer must get out of the old rut of letting things slide along in the easiest way if he wishes to remain in the good graces of his employer and rise in his position. Attention to the little details and keeping the engine and boiler room neat and clean will impress an owner or manager as much as ability to repair a breakdown in a rush or skill in operating. In fact, breakdowns are not tolerated in the modern plant except in the most extreme cases, and economical operation is paramount.

The engineer can, if he will, save his employers considerable money by doing some of the little things that in many cases are turned over to outside help. Take the piston rods of boiler-feed pumps, for instance. I have found them badly worn, with shoulders at each end, and instead of sending them to a shop to be turned up I have done a very business-like job with a file and made them last twice as long before sending them out for repairs. If the piston rings of the steam cylinders are too loose and leak steam, take them out and peen them lightly all the way around on the inside with a ball-peen hammer. This will expand and set them out against the cylinder wall and make a tight fit. The hammer should be used very lightly or else the rings will be expanded too much.

More or less trouble is caused by the locknuts on the piston rod in the water end of pumps coming loose. This can be prevented by drilling a hole through the rod just back of the outside nut and inserting a cotter pin or a copper wire to keep the nuts in place.

In one plant that I was operating two pumps were taken from another plant and installed for boiler-feed service. The brass valve cages of these pumps were loose when received, and the bonnets of the pumps were so badly worn that the cages would leave their seats. I drilled holes in the edge of the cages and tapped them for countersunk screws, but this did not prove a success. I then had a ¼-in. brass plate cast which took in the whole top of the pump and fitted over the cages. This held the cages in place, and the pumps were practically as good as new.

Vacuum pumps to work successfully need constant care. Particular attention should be paid to pumps with piston steam valves. These need more oil than any other pump I have had experience with. In many cases I have taken such pumps apart when they were not working just right, and all they needed was a little more oil.

Care should be taken not to run a vacuum pump too fast. If this is done and you lose the head of water, so to speak, in the system the pump will almost invariably give trouble. In making this statement I have particular reference to a heating system where a fan or blower is used and where the vacuum pump lines are in direct connection with the manifolds. In this case it is necessary to have water in the lines, otherwise air will be pulled into the system.

In a system of this kind I had considerable trouble with the manifolds and steam coils becoming airbound. I remedied the trouble by drilling and tapping each manifold for a ¼-in. pipe. At the end of the header I placed a regulating valve to control the outflow, which was run into the air duct. By properly manipulating this regulating valve so as to keep up a slight circulation from each header, I had no further trouble with cold coils or manifolds; all of them were of even temperature, and it was surprising how much hotter the air was when it entered the shops.

In shops where a large amount of heat is required it is necessary to be on the job during cold weather, especially if it gets down toward zero. One must know just how fast to run the fan engines to maintain the maximum temperature and obtain the most economical operation. Many engineers seem to think that the faster a blower engine is run the more heat will be delivered, but this is not so. If a certain speed is needed the temperature of the hot air entering the shops will be lowered. In heating buildings at night with live steam considerable fuel can be saved by connecting all the pump exhausts directly into the feed-water heater. I did this in one plant and raised the temperature of the feed water 60 deg.

It is evident that in any large plant the engineer has got to be on the lookout all the time for opportunities to improve the service or the operating economy of the plant. Slipshod methods and guesswork are things of the past. Cleanliness, neatness, attention to details and a wideawake attitude must be cultivated by the man who would succeed in this field. C. MOLTERN.

St. Bernard, Ohio.

Trouble with Loose Piston Head

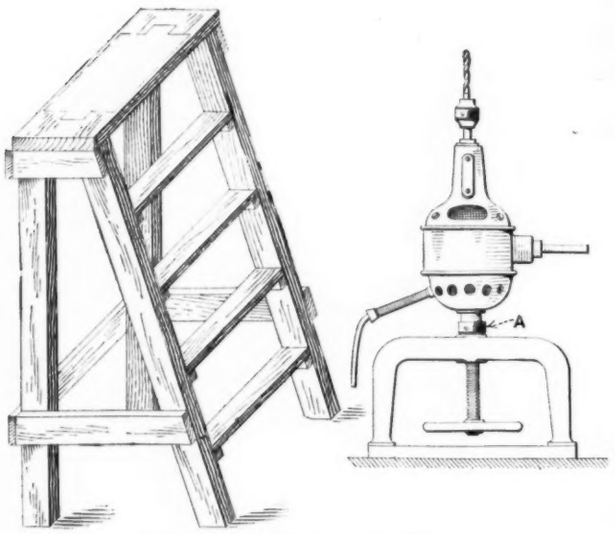
Referring to the questions asked by Thomas W. Airey, on page 149 of the July 27 issue, I think that it would have been better to have made the rod with the same taper and with a shoulder on the rod instead of giving it more of a taper.

The advantage of heating the piston and putting it on the rod while hot would be that with the rod cool and the piston hot and a good fit, it would contract and be much tighter when cool. D. G. SIMMONS.

Hudson, N. Y.

Device for Overhead Drilling

The illustration shows a kink that I used for overhead drilling. I had more than a thousand holes to drill, and I found that this apparatus did the work very quickly. An old copying press was used; the plate was discarded and the screw and wheel reversed, as shown. At *A* a coupling sleeve was made to fit on the screw and



RIG FOR OVERHEAD DRILLING

the electric drill. After removing the breast plate, the sleeve was easily made to fit in its place. The press was placed on the stand when drilling.

Pontiac, Ill. FRANK GIFFORD.

Where Should the Beginner Start?

On page 229 of the Aug. 10 issue of *Power* J. A. Lane has opened up an interesting subject in relation to where a beginner should start. But there is a question as to how many young men who, having spent their allotted time in the engine room, would go firing? Mr. Lane is correct in saying that they would be right in their glory to start in the engine room, but it is a safe bet that most of them when they see a fireman all black and sweaty, would say, "Not for mine." On the other hand, if all firemen knew as much about their boilers as engineers are supposed to know, there would be fewer accidents. I once had a fireman working for me who had been on that same job over twenty years and he could not put in a gage glass. He did not know what caused the draft, and he said that the ball on the safety valve lever weighs 300 pounds.

Where licenses for engineers and firemen are required, the young engineer and fireman must necessarily know their business, but in a no-license territory one finds some funny stunts. I live in a no-license district and once saw an engineer at a 550-volt direct-current switchboard close a main switch and then close the circuit breaker. It was just his bullheaded luck that the breaker stayed put.

I have been at the game less than four years and obtained my experience by traveling from plant to plant. Some say, stick to one plant. Very good, but in that case you know only what is in that plant. Outside of actual service, study and reading are the greatest help a young man can get. If the engineers of the present day were really engineers, they would use coal economically. You will see more economical operation in the one-man plants than you sometimes do in the plants carrying firemen. Why? Because where a man is his own engineer and fireman, he just naturally knows what he is doing.

It is a practice in some plants to employ illiterate and ignorant foreigners as firemen. This should be stopped. Why should an engineer be required to hold license and then have to be the brains of some foreigner fireman? There is no justice in it for the engineer.

Taking it all in all, the proper place to break in a beginner is in a power plant where he will eventually learn to do his own repair work. There are already too many plants sending outside for repairs when a really wise engineer could save that expense, provided the firm employing him supplied a few tools. C. F. DEWEY.

Sidney, Australia.

Coal Versus Oil Performance Chart

One of the first questions asked when it is suggested that a change in fuel be made from coal to oil or vice versa in a power plant, is whether it will pay to make the change or whether the cost of evaporation will go up or down. Calculations are usually made to determine the relation or relative value of the fuels in question, making use of the cost per ton of coal delivered at the plant, its heating value and the efficiency of the boiler plant when burning coal in the one case, in comparison with the results determined by making use of

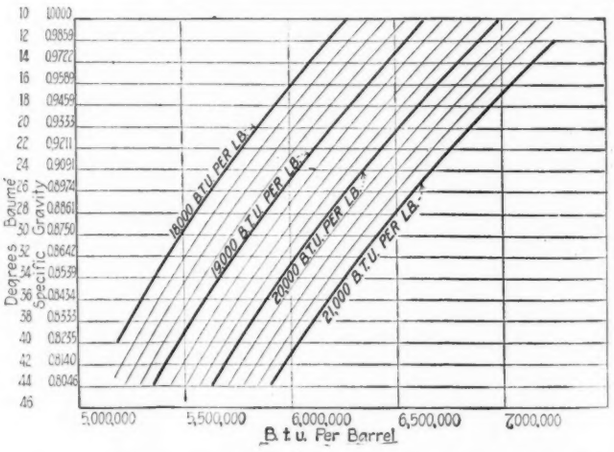


FIG. 1. HEAT CONTENT PER BARREL FOR VARIOUS GRADES OF FUEL OIL

the density of the oil fuel, the heating value per barrel, the cost per barrel delivered and the efficiency when burning fuel.

Everything except the efficiency when burning either one or the other fuel is known. In burning coal the efficiency obtained is known while it is problematical just what the efficiency will be when changed to oil burning. With large boilers, properly equipped with well-designed furnaces and burners it is possible to obtain an efficiency of 82 per cent. This, of course, will not ordinarily be obtained under actual operating conditions, but during test conditions when the operation is very carefully watched. Poor furnace conditions and operation will reduce the efficiency of an oil-

burning plant lower than if coal were used. So it can be said that under favorable conditions a higher efficiency can be obtained when burning oil than when burning coal, but it is unlikely in average plant operation that the efficiency when burning oil will be greater than while burning coal.

However, the matter of efficiency is one for each plant operator to decide for himself, as he is the one who knows what conditions are in his plant, and consequently can best say what efficiency may be expected.

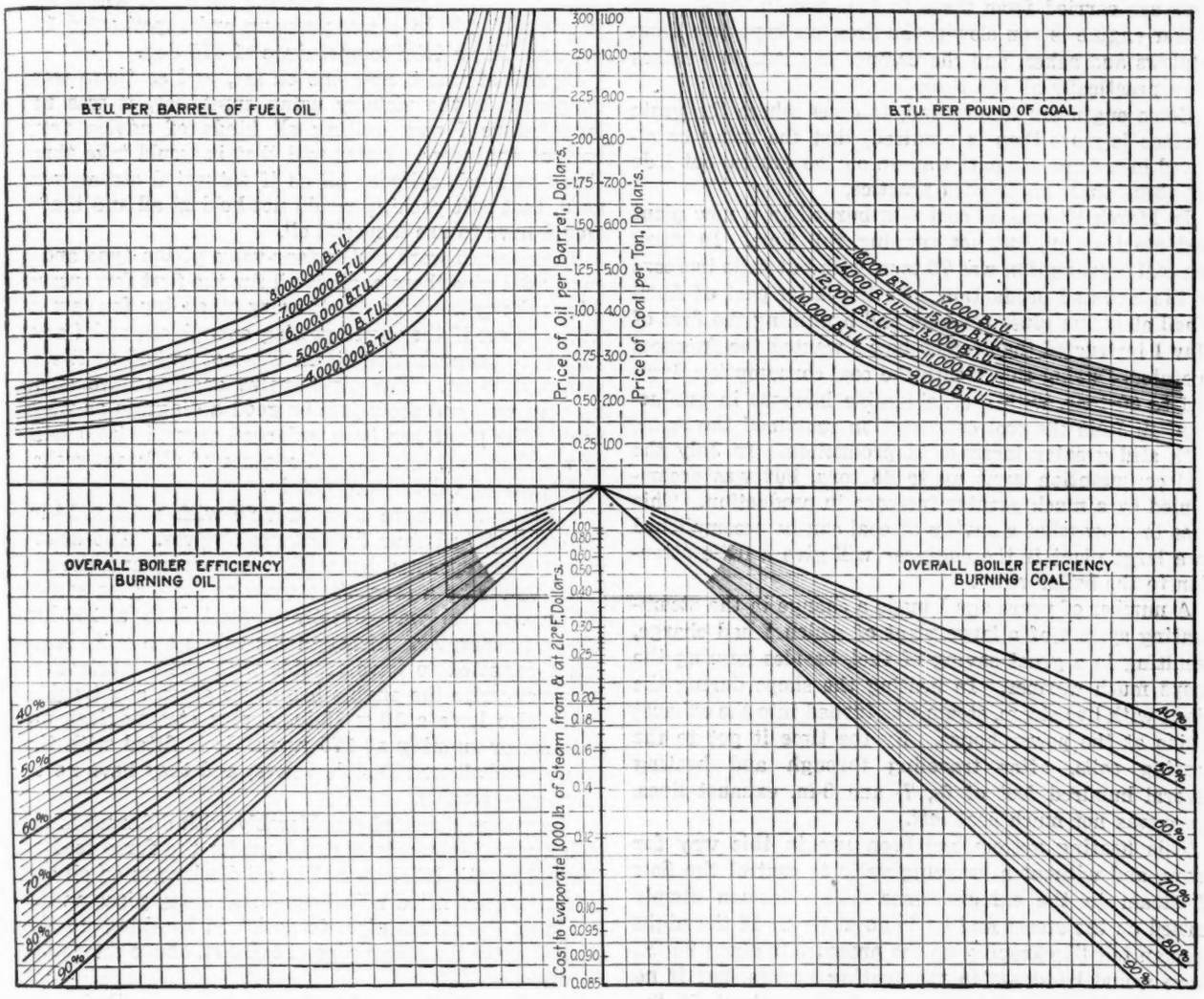


FIG. 2. COAL VERSUS OIL PERFORMANCE CHART

In making use of the accompanying chart, it is left to the operator himself to decide what efficiency he will get when changing from one fuel to the other. He should, however, be sure of his figures before making a change and also to be sure that an ample supply of fuel oil will be obtainable.

To make use of the chart, first determine the B.t.u. per barrel of the oil in question from the density-heat content chart, Fig. 1. Then referring to the coal vs. oil chart, Fig. 2, start at the cost per ton of coal and follow a horizontal line until an intersection is made with the B.t.u. per pound of coal; then follow a vertical line until intersecting the line representing the efficiency when burning coal; from this point proceed to the left, and the cost of evaporating 1,000 lb. of water from and at 212 deg. F. will be found. Proceed still farther to the left until intersecting the line representing the efficiency when burning oil; then follow a vertical line up until the curve representing the B.t.u. per barrel is reached; then follow a horizontal line to the right to the vertical line through the middle of the chart, and the cost per barrel of oil will be found which equals the cost of the performance using coal. The plotting line shown in Fig. 2 is made with the following assumption: Coal, $7 per ton; boiler efficiency, 70 per cent; B.t.u. per barrel of fuel, 5,500,000.

If the cost of oil is less than determined by the chart in the foregoing manner, it will pay to change to oil (not considering anything but cost of fuel). If not, it will, of course, be better to continue burning coal.

If burning oil, tracing lines around the chart in the opposite manner, starting with the cost per barrel of fuel and ending with the cost per ton of coal, will show what priced coal is equivalent to the oil being used.

L. C. LICHTY,
Assist. Prof. Mechanical Engineering
University of Oklahoma.
Norman, Okla.

Practical Fuel-Conservation Methods

Some time ago I took charge of a small plant, and in order to show what a little attention to details will do the results obtained are herein related.

The boiler-grate area in this particular case was much greater than the load demanded. A convenient means of controlling the damper from the front of the boiler was the first thing to receive attention, which was accomplished by placing a notched plate in front of the boiler, the notches being spaced two inches apart. The fires are carried from three to four inches thick. The stoker engine is run slowly, the fires are kept free from clinkers and ashes, and the damper is about two inches open practically all the time.

Some engineers recommend, in cases where the grate surface is more than is required, that the ashes be allowed to accumulate part way up on the grates, but I do not think that this is good practice.

In March 68 tons of coal was burned in a new plant just starting up, but not running full time. In April the coal consumption was 70 tons, with but little increase in the load and production By the latter part of April I had all steam pipes covered, and beginning the first of May I instructed the firemen how I wanted the furnaces operated. During this month the coal consumption dropped to 60 tons, with a considerable increase in production. In June the coal consumption remained the same, with still greater increase in production. In July the coal consumption went up to 66 tons, but was accompanied by a much greater increase in production. This goes to show what a saving of coal can be accomplished in a large plant if the engineer will give a little attention to the boiler room.

A number of years ago I made a change in the steam-heating system of a large plant of which I had charge, resulting in a great saving of fuel, besides keeping the shops much warmer. In heating the shops during the night with live steam, steam was turned into the exhaust mains at the power house. By the time it got to the heating coils, after traveling through and heating several hundred feet of 5-, 7- and 8-in. exhaust lines, there was not much heat left.

This heating system had been run in this way for years, and without a reducing valve to control the flow of steam to the exhaust lines. The fireman simply turned on the steam and let it go at that. If the night fireman felt like keeping up the pressure to about 95 lb., there would be steam in the heating system, but if he got sleepy and let the pressure drop to about 50 lb., the shops would be cold the next morning.

All I did to remedy this was to run a 1-in. steam pipe from the line supplying the blower engine of the heating coils directly into the coils, with a reducing valve in this pipe. This required but little piping and we obtained excellent results. the shops being warm every morning. After piping all the heaters in this way, I made a rough two-hour test on a mild day in February, which was hardly long enough to tell anything about it, but it served to give a line on what was being accomplished. By turning the steam direct into the heating coils at about two pounds pressure, we burned 1,980 lb of coal with a feed-water temperature of 186 to 188 deg. F. By turning the steam into the exhaust mains at the power house at about three pounds pressure, we consumed 3,300 lb. of coal with a feed-water temperature of 202 to 204 deg. In two hours' run there was a saving of 1,320 lb. of coal and in a twelve-hour run at night, using live steam, there would be saved at the same rate about three and a half tons of coal. In zero weather the saving would be considerably greater.

Cincinnati, Ohio. C. MOTTERN.

Superheated Steam in Small Plants

About ten years ago the company by which I am employed built a new steam plant, and I was sent from the machine shop to erect and operate the plant, which was to run with 120 lb. steam pressure and superheated 125 deg., making a total temperature of 475 deg.

Superheat was a new one on me, and as there were no plants in the vicinity using superheat, it was not long before I was getting all kinds of advice from various engineers. I was told that it would take three times as much cylinder oil as if saturated steam were used, that soft packing would not hold at all and that I would have to use a special oil.

The engines were of the four-valve piston type and I surely did give those engines oil for the first few weeks. I took the cylinder heads off every other day for several weeks to see if they were getting enough oil, and I soon found that superheated steam was not as bad as it was supposed to be. The piston-valve engines have stood up very well and show just as good a diagram as when new. The plant has been enlarged several times with new boilers, but second-hand engines of different makes and types of valves were put in.

I expected to have some trouble with a 16 x 14-in. engine that had four flat balanced valves. The steam valves were operated by a Rites governor, and the exhaust valves by a separate eccentric; the engine ran at 250 r.p.m. and was directly connected to a 100-kw. 110-volt generator. Although the valves are quite large and I expected to have trouble with their lubrication, to my surprise the engine has never given any trouble.

We also have a 10 x 10-in. duplex steam-driven air compressor running at 175 r.p.m. It is fitted with the regular unbalanced D-slide valves, and they have never given any trouble.

I have experimented considerably with different kinds and types of lubricators, and I prefer the force feed to the hydrostatic lubricator. The oil discharges on all our lubricators are fitted with home-made spray pipes on the inside of the steam pipe, to assist in breaking up the oil, and enter the steam pipe about 4 ft. above the throttle valve.

The 16 x 14-in. engine is the only one that uses metallic packing; all of the others are packed with asbestos piston-rod packing.

I think there are many engineers and small-plant owners who are in the same boat I was. When they think superheated steam they think of trouble, but I know from experience that the average slide-piston and Corliss-valve engine will stand 475 deg. heat with no more and perhaps with less trouble than would be experienced with saturated steam.

The first superheaters have been in use about ten years and have never cost one penny for repairs. The temperature is very uniform, never varying more than a few degrees. The dust or soot is blown off every other day with a steam lance, which takes only a few minutes for each boiler. JOSEPH GERBER.

Dansville, N. Y.

INQUIRIES OF GENERAL INTEREST

Solid Piston and Built-Up Piston—What is the difference between a solid piston and a built-up piston? W. E. T.

When a piston is of one piece, whether cast solid or hollow, it is usually termed a "solid piston." A built-up piston is one that is built up of a number of parts and usually with facility for adjustment at right angles to the cylinder center line.

Leakage of New Corliss Valves—After having valve seats of a Corliss engine rebored and new valves fitted, we are disappointed to find considerable leakage. How can the trouble be remedied? B. R. T.

The valves become warped from heat of the steam, and the high spots shown by the wear should be taken down by a good job of draw-filing. The valve should be examined after a few days' run and have any remaining high places removed with a smooth file or scraper and if the work has been carefully done the valves will soon come to a permanent good bearing.

Preference of Poppet Valves for Superheated Steam—Why are poppet valves used on engines intended to be supplied with superheated steam? M. F. J.

Poppet valves are preferred because large valves and valves with rubbing surfaces, such as slide valves and Corliss valves, do not work well with highly superheated steam as warping of the contact surface from high temperatures and lack of moisture, which acts as a seal with saturated steam, leads to excessive leakage and, in addition, more or less difficulty is experienced in lubricating the sliding surfaces.

Trouble from Crumbling Firebrick—We are experiencing considerable trouble with the firebrick of a boiler setting. When a brick is barely touched, it falls to pieces. Would operating conditions be the cause of this? J. B. S.

If the firebricks disintegrate from alternate heating and cooling with gradual changes of temperature, they may not be of high enough grade for the type of furnace, kind of fuel and intensity of firing that is practiced. But firebrick of most any grade is likely to spawl and crumble if the brickwork of the boiler setting was not thoroughly dried out before the boiler was put into service, or if the setting is alternately exposed to firing and moisture, whether derived from damp air, steam or direct wetting by water.

Power Factor of Induction Motors—What would be a conservative value for the full-load power factor and efficiency of a 60-cycle two-phase 220-volt 450-r.p.m 3¾-hp. squirrel-cage motor of modern design? H. N.

Both the power factor and efficiency of a squirrel-cage induction motor are affected to a greater or less extent by the frequency, number of poles and length of gap. Motors operating on 60 cycles have a higher efficiency than when designed for 25 cycles, whereas motors with a large number of poles operate at a slow speed and have a low efficiency and power factor. The motor in question runs 450 r.p.m. on 60 cycles. Consequently, it has 16 poles, which is an exceptionally large number for a motor of its size and frequency. Therefore, the full-load power factor and efficiency will probably not be more than 75 per cent for either factor.

Limitation of Cutoff with D Slide Valve—Why is it not practical to use a D slide for a steam engine to cut off earlier than ½ to ⅝ stroke? H. C. C.

For cutting off shorter than ½ to ⅝ of the stroke, the angle of advance of the eccentric, the amount of steam lap, and the size of the eccentric must all be made very large, resulting in increase of valve friction and also in very early release and excessive compression.

Leaving Current Transformer in Circuit—Will a current transformer that has been connected to an instrument be injured if it is disconnected and left in circuit indefinitely with its socondaries short-circuited? V. K. S.

The resistance of the current coil of an electrical instrument designed to connect to a current transformer is very low, therefore when the secondary terminals of the transformer are short-circuited the resistance of the secondary circuit is not materially changed. The standard current transformer is designed for 5 amperes in the secondary when the primary is carrying full load. Since the transformer is connected in series in the circuit, the secondary current is limited by the primary current; consequently, if the secondary is short-circuited, the current will not exceed the value determined by the ratio of the transformer and will not be burned out if the secondary terminals are short-circuited. On the other hand, if the secondary terminals are left open-circuited, when full load comes on there is danger of the transformer being destroyed, either from the high magnetic density in the core causing overheating, or the high voltage induced in the secondary may break the insulation down.

Sources of Engine Back Pressure—What are the causes of back pressure on an engine? R. G. L.

All conditions tending to raise the pressure of the exhaust steam, as by the addition of heat, compression, or obstruction to delivery into the atmosphere or condenser, are contributive to back pressure. Back pressure on the piston is increased by greater load on the engine, later release of steam after its expansion from tardiness in opening of the exhaust valves or earlier closing of the exhaust valve with increase of compression. Other causes contributive to back pressure are: Leakage of live steam past the piston or of the steam valve during the exhaust stroke; heat received by the exhaust steam from the cylinder walls; obstruction of the discharge through the exhaust port and passages, or connections and passages through an exhaust-steam feedwater heater; frictional resistance of the exhaust pipe due to bends and fittings and pipe friction that increases with the length and reduction in size of opening of the exhaust pipe; obstruction of the discharge by a condenser head or a back-pressure relief valve; and the pressure acquired for overcoming the pressure of the atmosphere or that of a condenser into which the exhaust is finally discharged and absorbed.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications.—Editor.]

American Chemical Society

In connection with the American Chemical Society meeting in Chicago the week of Sept. 6, an extended series of papers will be presented on fuel problems. The headquarters of the society will be the Congress Hotel, Chicago, but the Fuel Symposium will be held in the laboratories of the University of Chicago on Thursday afternoon, Sept. 9, under the chairmanship of A. C. Fieldner. The following papers will be presented: S. W. Parr, "Low Temperature Carbonization"; Edgar Stansfield, "Carbonization of Canadian Lignites"; Henry Kreisinger, "Byproduct Coke, Anthracite and Pennsylvania Coal as Fuel for Heating Houses"; F. W. Sperr, "Byproduct Coking"; G. A. Burrell and others, "The Charcoal Method of Gasoline Recovery"; S. E. Sheppard, "Colloidal Fuels—Their Preparation and Properties"; A. C. Fieldner and others, "Gasoline Losses due to Incomplete Combustion in Motor Vehicles"; J. B. Garner, "Enrichment of Artificial Gas with Natural Gas"; Harry A. Curtis, "Commercial Realization of Low-Temperature Carbonization of Coal"; H. C. Porter, "Fuel Conservation, Present and Future"; Alfred B. Powell, "Some Factors Affecting the Sulphur Content of Coke and Gas in Carbonization of Coal"; H. F. Yancey and others, "Distribution of the Forms of Sulphur in the Coal Bed."

Water-supply problems will also be considered by the society in connection with the meetings of the Division of Water, Sewage and Sanitation. A. S. Behrman will discuss the question of "Water Softening for the Manufacture of Raw Water Ice," and W. D. Collins will give a report from his work in the United States Geological Survey on the subject, "Hardness of Surface Waters in the United States."

The general sessions of the society will deal with the problem of increased production by industries. "The Relation of Educational Institutions to Industries" and "The Value of Technical Training in Reconstruction of Industries" will be discussed respectively by Prof. H. P. Talbot, of the Massachusetts Institute of Technology, and Thomas E. Wilson, president of Wilson & Co. of Chicago.

Westinghouse Scholarships

The War Memorial Scholarship Committee of the Westinghouse Electric and Manufacturing Co. has announced as the winners of the four scholarships for the coming college year, 1920-21; Alva C. Corrao, Small Motor Drafting Department; Henry Gardiner Symonds, son of N. G. Symonds, Manager Industrial Sales Division, Chicago Office; J. Dale Seabert, Transformer Engineering Department; and Herbert R. Hillman, son of William A. Hillman, who has been a machinist in the works of the R. D. Nuttall Co. for 27 years. These War Memorial Scholarships were established in 1919 as a means for perpetuating the memory of those employees of the Westinghouse Electric and Manufacturing Co. and its subsidiary companies, who took part in the World War. Each Scholarship carries with it an annual payment of $500 for a period not to exceed four years. The payment is to be applied toward an engineering education in any technical school or college selected by the successful candidate and approved by the Scholarship Committee. Scholarships are granted for one year only, but are continued for the full course provided the scholar maintains the academic and other standards required by the institution.

The average production for each underground worker employed in the coal mines of the United States during 1918 was 1,134 short tons according to statistics given out by the Bureau of Mines, Department of the Interior. The closest competitor of this country is New South Wales where each underground worker in 1918 produced 814 tons. British Columbia ranked third with 790 tons and Nova Scotia was fourth with 718 tons. The smallest individual output for recent years was that of Japan in 1917, when an average of 155 tons was mined by the underground employees.

Bituminous Prices Decline

The coal situation is better than it was a few weeks ago. More cars are available, production in most fields has been higher, and prices in some sections are lower. Of course there are exceptions, as in Cleveland, where the deadlock reached between operators and union heads has had an unfavorable effect upon mine labor, resulting in intermittent strikes and general dissatisfaction. In St. Louis the steam situation is fairly satisfactory, but stocks are on a day-to-day basis except in the case of a few big plants and the public utilities. The car scarcity seems to be most acute in the Birmingham district, the Southern Railway furnishing only 25 per cent of the number needed. The Louisville & Nashville R.R. on the other hand has been able to supply 100 per cent, while the Frisco is supplying 70 per cent of the cars required in the field it serves.

Easing Up Along Atlantic Seaboard

The Boston market can be measured by the day-to-day quotations on spot coal. In the last week pool 11 grade declined $1.25, the last price offered being $9.50. Prices down to $7 at mines have been rumored on coal for shipment via Tidewater, but there appears to be very little buying interest owing to contracts that the manufacturers have with the mines. The only traffic restriction in effect at present is an embargo against coal moving via West Albany for B. & M. and N. Y., N. H. & H. destinations.

A better car supply has resulted in increased shipment and lower prices. Pool 10 was quoted at $9 to $10 at mines and about $16.50 alongside dock. For Pool 11 mine quotations ranged from $8.50 to $9 and $16 alongside.

Prices began to settle gradually in Philadelphia three weeks ago and the decline continues. Pennsylvania steam coal is available at about $11 at mines. Grades are again regrouping themselves, indicating that the market is becoming more regular.

A better run of cars and the curbing of speculation has produced a weaker market in Baltimore. Coal is selling at the mines at $9.50 to $10 per net ton for best fuels on the B. & O. R.R. Similar coals on the Pennsylvania R.R. delivery connections sell on a mine basis of $11 to $13.

Inland Prices Are Firm

The Chicago market is spotty. Some of the Franklin County operators have raised prices, one firm selling Franklin County prepared coal through its regular channels on the basis of $5.50 f.o.b. mines, which is about $1 higher than the price asked by other Franklin County operators. Southern Illinois open-market prices are much higher. The car supply is much improved as is also the time in transit of coal from mines through to destination. Eastern coals are coming into the Chicago market in greater volume than expected. Pocahontas coals sell at retail for $12 to $15.

Cincinnati coal companies that receive their fuel by boat have not increased prices. The net increase in the rail freight from the West Virginia mines to Cincinnati is 61c. per ton, and on anthracite $1.73 per ton There are ample stocks and no complaints from industries or public utilities.

Reports from Columbus state that production has increased in all districts owing to an improved car supply. On the Hocking Valley R.R. the supply was almost 100 per cent; on the Toledo & Ohio R.R. the supply also was good, while Eastern Ohio is credited with about 64 per cent, which is a marked improvement. The advanced freight rates were expected to have some influence on prices, the increases being 40c. from the Hocking Valley and 66c. from the Kanawha field.

In the Middle West prices are as follows: Franklin County and Southern Illinois prepared coals, $4.75 to $8.50; Springfield District, $6.25 to $8.50; Northern Illinois thin vein coal, $5.75 to $7.50; Clinton Fourth Vein from Indiana, $4.50 to $8; Indiana Fifth Vein, $4.25 to $7.25.

Difficulties with mine labor in the Middle West have been settled for the present, and early last week the men began going back to work both in Illinois and Indiana. On Aug. 25 practically all the larger mines were working The demand for coal in the Middle West is as heavy as ever and the market prices on all grades are reported erratic.

Obituary

Professor John Perry—The death of Professor John Perry in his seventieth year, on Aug. 4, recorded the passing of one of England's foremost engineers and authors. His books, papers and lectures on engineering subjects have been widely read, and he contributed during his long period of service in no small measure to the advancement of engineering knowledge. Professor Perry was born in Ulster, in 1850, and received his technical education at Queen's College, Belfast. From 1870 to 1874 he was assistant master in Clifton College. He resigned and became professor of engineering in Japan, where he remained until 1879. Between the years 1879 and 1895 he accepted the position of professor of engineering and mathematics, City and Guild of the London Technical College, and later professor of mechanics and mathematics in the Royal College of Science, South Kensington. He was actively associated with many engineering societies. He was a past president of the Institution of Electrical Engineering and past treasurer of the British Association. He was the author of a number of books, including "The Steam Engine," Practical Mechanics," "Hydraulics," "Applied Mechanics" and many others.

Personals

Irving C. Baker is now plant engineer for the Maryland Motors Corporation, Laurel, Md.

The Charles T. Main organization includes in its personnel William Frank Uhl, as hydraulic engineer, and Charles R. Main, as special assistant.

Herman B. Scharnberg has resigned his position with the Haitian American Corporation and has taken the position of chief engineer with the Palma Sugar Co., Central Palma, Oriente, Cuba.

Louis H. Blood has resigned as chief engineer of The Oesterlein Machine Co., and has opened an office in Cincinnati as designing engineer, specializing on the design of standard and special machine tools.

Walter Rautenstauch, professor of mechanical engineering, Colubia University, has recently joined the J. C. White organizations as vice president of The Management Corporation, in charge of Industrial properties.

Milton C. Stuart, formerly senior mechanical engineer at U. S. Naval Engineering Experiment Station, Annapolis, Md., has been appointed professor of mechanical and marine engineering at the Naval Postgraduate School, Annapolis, Md.

Wallace E. Tillinghast, managing owner, Massachusetts Steam Specialty Co., will be in direct control and supervision of the department of diplomatic and advisory engineering which that company has recently organized.

William D. Ennis announces his resignation as professor of mechanical and marine engineering in the Postgraduate School of the U. S. Naval Academy to become vice president of the Technical Advisory Corporation of New York. Mr. Ennis has been associated with the latter corporation since its organization and will hereafter be located at its general offices in New York City

C. W. Willette, after many years of investigation and study of the requirements on the Pacific Coast, has brought out an entirely new type of sawmill machinery, and has concluded a contract with the Puget Sound Machinery Depot, of Seattle, Wash., for the manufacture of this machinery in connection with their own, under his personal supervision as chief engineer of the milling department. Mr. Willette is located in Portland, Ore.

General George H. Harries and **Samuel E. Doane** are among the newly elected officers of the Illuminating Engineering Society, who will assume office in October. General Harries has been prominent in the electrical field for over twenty-five years, engaging in electrical engineering and construction. Mr. Doane is also well known in the electrical field, having specialized in standardization work, one of his papers on this work being instrumental in the establishment of the Bureau of Standards. General Harries, as new president of the Illuminating Engineering Society, and Mr. Doane, as junior past-president, will both serve on the Council of the Society for the coming year.

Charles Whiting Baker, for many years editor-in-chief of *Engineering News* and since 1917 consulting editor of *Engineering News-Record*, announces his resignation and the establishment under his direction of The Engineering Business Exchange, 31 Nassau St., New York. The new firm will act as a clearing house for those having an engineering or technical business for sale, and others who are interested in considering an investment in such properties. Mr. Baker is a graduate of the University of Vermont, class of 1866. After graduating, he became an associate editor of *Engineering News*. In 1895 he became editor-in-chief, acting as such until 1917, when he was made consulting editor of *Engineering News-Record*. He is a member of the American Society of Mechanical Engineers, of which he was vice president from 1909 until 1911; American Society of Terminal Engineers, vice president, 1919-1920; Engineering Council since organization in 1917, representing A. S. M. E., Chairman Committee on Public Affairs; secretary, Council's Committee on Classification and Compensation of Engineers and of the Executive Committee National Public Works Department Association.

Society Affairs

The New England Section of the National Electric Light Association will hold its annual convention at Kineo, Maine, Sept. 13 to 16 inclusive.

The Association of Edison Electric Illuminating Companies will hold its annual convention at the Hotel Griswold, New London, Conn., Sept. 13 to 16 inclusive.

The Illuminating Engineering Society, fourteenth annual convention will be held at Cleveland, Ohio, Oct. 4 to 7. A number of interesting papers will be read including, "Central Station Methods for Securing High Lighting Standards in Stores and Homes," and "Central Station Experience in the improvement of Factory Lighting."

The Pennsylvania Electric Association will hold its annual convention at Bedford Springs, Pa., Sept. 8 to 11. At the technical session on Sept. 10 the following addresses and papers will be delivered: "Coal Supply and Distribution," address by J. D. A. Morrow; abstract of the report on Power Factor, as prepared by representatives of the Philadelphia Electric Co., "Coal Storage," address by O. P. Hood, Chief Engineer, Bureau of Mines, Washington, D. C.

The American Association of Engineers, in continuation of plans inaugurated last year by a number of chapters, is planning educational courses which will place at the disposal of members a variety of courses not usually accessible to engineers. The Twin City Chapter has arranged with the general extension division of the University of Minnesota to form evening classes in various subjects. The classes will be instructed by members of the faculty of the university and by the leaders in professional practice outside the university. Courses are offered in the following technical subjects: Architectural history, architectural design, freehand drawing, map drawing, surveying, railroad engineering, structural design, reinforced concrete, elementary electricity, direct and alternating current machinery, power-plant design, shop mathematics, applied mechanics, heating and ventilating, water power, municipal engineering and highway engineering.

The Sixth National Exposition of Chemical Industries will be held in Grand Central Palace, New York City, Sept. 20-25. On the afternoon of Thursday, Sept. 23, the Chemical Engineering symposium will take place. The American Institute of Chemical Engineers will hold a meeting in the Palace in the afternoon, and papers will be read. In the evening the engineers will have a dinner at the Technology Club. Three other symposiums will be held during the week. One will be on "Fuel Economy," one on "Materials Handling," and one on "Industrial Management." The Fuel Handling Division and the Material Handling Division have developed such progress that it is necessary to give each a separate section at the coming exposition. Important topics will be discussed on the days these two divisions meet.

Miscellaneous News

The Shipping Board announces that it has entered into a contract with the Atlantic Gulf Oil Corporation for supplying crude and fuel oil to be delivered over a period of one year beginning on or about Jan. 1, 1921, in cargo lots at the supplier's terminal, Tecomate, Mexico, as follows: 6,000,000 bbl. of fuel oil at $1.25 per bbl., including taxes; 9,000,000 bbl. of crude petroleum at $1.25 per bbl., including taxes. The Shipping Board is to provide the tank steamers to transport the oil.

The Narragansett Electric Lighting Co., of Providence, R. I., is planning to install a 45,000-kw. two element cross-compound Westinghouse turbine-generator. This unit will be operated at 210 lb. pressure, 125 deg. superheat and 28½ in. vacuum. The generator will be three phase 60 cycle 11,000 volts. To go with the generating unit, 36,000-g.p.m. twin jet condensers will be installed. These condensers will be steam-turbine and gear driven. The installation is interesting because the unit now installed is the largest generating unit in the world which is equipped with jet condensers. It will be remembered that the 45,000-kw. unit now installed at this station recently completed what is thought to be the world's record for a continuous run of large triple-expansion cross-compound turbine-generators. In fact, it has operated 84 days without being shut down.

New Construction

PROPOSED WORK

Mass., Cambridge—The A. R. Hyde Co., 432 Columbia St. had plans prepared for a 1 story, 20 x 40 ft. power house at its factory. Estimated cost about $20,000. Tuck & Gilman, 34 School St., Boston, Engr.

Conn., Middletown—A. Brazos & Sons, Inc., 68 Oak St., is in the market for a 50 or 60 hp. mounted boiler and an engine.

N. Y., Richmond—The Dept. Pub Welfare, Municipal Bldg, New York City, will soon receive bids for the installation of boilers in the present boiler house at Sea View Hospital, here. Former bids recalled.

Md., Baltimore—The American Can Co., 120 B'way, is having plans prepared for a factory including a steam heating system. About $500,000.

Md., Baltimore—Samuel T. Williams, 223 North Calvert St., is in the market for a steam heating boiler rating from 2100 to 2,500 sq.ft. capacity and a 2 stage, duplex, belt-driven air compressor, 270 to 400 cu.ft. of free air per minute to 100 lb. pressure.

Va, Fort Monroe—The U. S. Army, Construction Div., Wash., D. C. plans to build a new booster pump house here.

Va., Richmond—The Pearl Laundry, 6 South 12th St. is in the market for a 25 to 30 hp. new or used motor.

Va., Richmond—J. E. Candle, 316 North 3rd St., is in the market for one motor.

Va., Richmond—W. H. Sickel, 409 West Broad St., is in the market for electric motors.

Va., Richmond—D. Heyward, 715 West Broad St., is in the market for a 30 or 40 ton ice plant.

S. C. Charleston—The Bureau of Yards and Docks, Navy Dept., Wash., D. C. plans to make improvements to boiler plant here.

Fla., Jacksonville—The Florida Christian Home is having plans prepared for alteration of present buildings, installation of new heating plant, etc. About $50,000. J. H. Lynch & Son, Dolf Bldg., St. Louis, Mo., Archts. and Engrs.

O., Akron—The Loew Theatrical Enterprises, 1493 B'way, New York, N. Y. will soon award the contract for a theatre and arcade on South Main St., including steam heating system. About $500,000. C. Howard Crane, 2325 Dime Bk. Bldg., Detroit, Mich., Archt. and Engr.

O., Bellaire—The City plans to issue $30,000 in bonds to improve the waterworks system and purchase pumping machinery.

O., Carey—The city council plans to reconstruct the distribution system here. Plans will include either a power plant or the erection of transmission lines. About $90,000. Froehlich & Emery, 2nd Natl. Bank Bldg., Toledo, Engrs.

O., Cleveland—J. H. Rooke, 507 Williamson Bldg., had plans prepared by W. W. Hodges, Archt. and Engr., Lennox Bldg., for a 4 story, 200 x 280 ft. factory, including steam heating system. About $250,000.

O., Cleveland—The City, care of G. Beckwith, City Hall, will purchase wire, cables, transformers and equipment, meters and service equipment for the municipal electric light plant. About $100,000.

O., Columbus—The Cotter Warehouse Co., Schultz Bldg., is in the market for conveyors, portable elevators, etc., for its plant here. About $30,000. W. L. Cotter, Pres.

O., Lorain—The Bd. Educ. is planning to build a 3 story high school including steam heating system at East 31st St. and Seneca Ave. About $300,000. F. C. Warner, Hippodrome Annex Bldg., Cleveland, Archt.

Mich., Detroit—The Bd. Educ., 50 B'way, received bids for heating, ventilating and plumbing systems in the Leland School addition from the Drake Avery Co., 40 State St., at $91,915; for the Carstens School from W. J. Rewoldt, 506 Owen Bldg., $62,108. Irvine & Meier, 2289 Woodward Ave., $64,389; Copper School from J. W. Partlan, 51 Park Pl., $93,800; Crossman School addition from Drake Avery Co., 40 State St., $51,821. J. W. Partlan, 51 Park Pl., $53,886, O'Connor Bros., Owen Bldg., $54,195. Noted July 13.

Mich., Detroit—The city council has ordered estimates to be prepared for a proposed 2 story, 250 x 600 ft. memorial building, including steam heating equipment. John A. Kronk, City Hall, Chmn of Comm.

Mich., Detroit—The Ft. Shelby Garage, care of John Gillespie, Ft. Shelby Hotel, plans to build a 4 story, 130 x 150 ft. garage on Howard and 1st Sts. Steam heating system, boiler, ash handling equipment, etc. will be installed. Albert Kahn, Marquette Building, Archt.

Ill., Granite City—The Bd. Educ. will receive bids until October 1 for a 3 story high school. Power plant for heating will be installed in same. About $225,000. William B. Ittner, Bd. Educ. Bldg., St. Louis, Mo., Archt. Noted August 10.

Ill., Roscoe—The Rockford & Interurban Ry., Rockford, plans to install a transformer, here. About $4,500.

Minn., Bemidji—The Bd. Educ. plans to build a 3 story high school including steam heating system. About $500,000.

Minn., Minneapolis—The Franklin Cooperative Creamery Co., 26th St. and Franklin Ave., care of Edward Solem, 11½ Western Ave., has plans under way for a 1 story, 64 x 85 ft. creamery. About $25,000 to be expended on power and refrigerating equipment.

Kan., Dodge City—The Midland Ice & Light Co. will soon receive bids for a 1 story, 56 x 62 ft. boiler house. Mann & Gerow, Hutchinson Archts. H. A. Noble, 411 Reliance Bldg., Kansas City, Mo., Structural Engr.

Kan., Wakeeney—H. Long, city clk. will receive bids until September 17 for power plant, for providing necessary equipment including generators, exciters, etc. and furnishing labor. Black & Veach, Mutual Bldg., Kansas City, Mo., Engrs.

Mo., Kansas City—The Ford Motor Co., Highland Park, Mich. will soon award contract for a 1 story, 175 x 535 tractor assembly plant. Steam heating system will be installed. Albert Kahn, 58 Lafayette St., Detroit, Mich., Archt.

Mo., St. Louis—The Bowen Motor Railway Co., Title Guaranty Bldg., plans to build a factory and power house. About $385,000. O. J. Popp, Odd Fellows' Bldg., Archt.

Okla., Purcell—The city will hold an election soon to vote on $382,000 bonds for new water supply and filtration plant, improvements to the electric light plant, etc. Johnson & Benham, Firestone Bldg., Kansas city, Mo., Engrs.

Idaho, Boise—The Idaho Power Co. has been requested by residents of Wilder and Homedale to extend its transmission lines from here. Plans include sub-station, distribution system, 7.5 miles volt line, etc. Estimated cost about $51,000.

Utah, Brigham—The city plans an election on September 10 to vote $250,000 bonds for addition to municipal electric plant to increase capacity to 1,500 hp. C. O. Roskelly, Engr. Noted May 3.

Ore., Salem—R. B. Goodwin, Secy. Oregon State Board of Control, will soon award the contract for labor and materials for heating and plumbing systems in the 2 story dormitory to be built near here, for the State Institution for Feeble-Minded.

Ore., Salem—M. J. Anderson of Portland has applied to the state engineer for permission to divert water for the development of 13,000 hp. on the south fork of the Coquille River. Estimated cost of project about $750,000.

Cal., San Diego—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., received bids for cold storage plant at Marine Base here, from C. M. Gay Co., 2650 Sante Fe Ave., Los Angeles, $24,000; T. Haverty, 801 Maple St., Los Angeles, $44,000. Noted June 8.

N. B., St. John—The Dept. Pub. Wks., Ottawa, Ont. will soon award the contract for alterations and additions to the steam heating apparatus in the Immigration Building here.

Ont., London—Frank W. Ruggles, Alma, Mich. will soon award the contract for the first of a series of buildings for the manufacture of auto trucks to be built on East London St., here. Steam heating system will be installed in same. About $2,000,000.

Ont., London—The Utilities Commissioners are in the market for one electrically driven waterworks pump, capacity of 500,000 Imp. gal. per day. E. V. Buchanan, Hydro Bldg., Gen. Mgr.

Ont., London—Watt & Blackwell, Archts., Bank of Toronto, will soon award the contract for the construction of a 3 story, 55 x 165 ft. children's hospital for the Daughters of the Empire. Hot water system, 3 boilers, pumps, motors, etc. will be installed. About $250,000.

Ont., Newbury—The City Council plans to construct an electric light and power distribution system here and is in the market for material and equipment. About $10,000. Chas. Tucker, Engr.

Ont., Toronto—Mayor T. L. Church, room 12, City Hall, will receive bids until September 14 for two 300,000 Imp. gal. per day, vertical centrifugal pumps with electric motors against 320 ft. head.

Ont., Welland—The Joseph Stokes Rubber Co., Broad St. Bank, Trenton, N. J., plans to build a 120 x 160 ft. factory and a 50 x 50 ft. power house, here. Plans include installation of two 150 hp. boilers, 2 pumps, air compressor, etc. About $100,000. Karno-Smith Co., Broad St. Bank, Trenton, N. J., Engrs.

CONTRACTS AWARDED

N. H., Winchester—The Winchester Tannery Co. has awarded the contract for a 1 story, 40 x 52 ft. boiler plant to Robt. F. Carroll, Keene, N. H. About $20,000.

Mass., Westfield—The Certified Food, Inc., plans to build a 1 story, 50 x 100 ft. cold storage plant. About $30,000. Work will be done by day labor.

Conn., Bridgeport—The United Illuminating Co., 84 Temple St., New Haven, has awarded the contract for the superstructure of a 1 story, 140 x 150 ft. power plant on East Main St., here, to Casey & Hurley, 120 Pequonnock St. Total est. cost $1,500,000.

Conn., Middletown—The Goodyear Rubber Co., 114 Church St., has awarded the contract for a boiler house to D. O'Brien & Sons Co., Inc., 118 Asylum St., Hartford. About $50,000.

Conn., New Britain—The Connecticut Light & Power Co., 111 West Main St., Waterbury, has awarded the contract for a 1 story, 45 x 90 ft. sub-station on Church St. here, to Wm. E. Burk, 76 Robbins Ave. About $40,000.

N. Y., New York—The Menbridge Realty Co., care of Gronenberg & Leuchtag, Archts., 303 5th Ave., will build a 2 story, 100 x 115 ft. theater and showroom building, including steam heating system. About $250,000. Work will be done by day labor.

N. Y., New York—M. Klaw, Commercial Trust Bldg., has awarded the contract for a theater building on 45th St. between B'way and 8th Ave. to Jardin Co., Inc., 507 5th Ave. Steam heating system will be installed in same. About $300,000. Noted June 1.

N. Y., New York—The Lawyers' Mortgage Co., 59 Liberty St., has awarded the contract for an office building at Maiden Lane and Nassau St., including steam heating system, to Cauldwell-Wingate Co., 381 4th Ave. About $1,500,000.

N. J., Camden—The Victor Talking Machine Co., Front and Cooper Sts., has awarded the contract for a 1 story, 53 x 200 ft. power house to the White Construction Co., 95 Madison Ave., New York, N. Y. Noted Aug. 10.

N. J., Trenton—The Mutual Pottery Co., Clinton Ave., has awarded the contract for buildings from 1 story to 5 stories including power house to Stone & Webster, 120 B'way, New York, N. Y. About $500,000.

Md., Baltimore—The Coca-Cola Co., care of S. L Willard, resident manager, Pratt St. and Market Pl., has awarded the contract for a 4 story 196 x 534 ft. coca-cola factory and cooperage plant, to A. Tufts Co., Chandler Annex, Atlanta, Ga. Steam or hot water heating system will be installed in same. About $1,250,000.

Tenn., Jacksonville—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., has awarded the contract for the removal of boilers from here and the re-erection of same at Portsmouth, Va., to Clarence J. Eisinger, 141 7th Ave., Brooklyn, N. Y., $33,136, 150 days.

Ky., Covington—The City Ice Co., 3210 Jefferson Ave., Cincinnati, O., has awarded the contract for a 42 x 136 ft. ice factory on 2nd and Scott Sts., here, to Wisenall & Bell, Covington. About $30,000.

O., Cleveland—The American Stove Co., Perkins Ave., has awarded the contract for a 1 story, 21 x 35 ft. boiler room at 43 Hough Ave. to the Boldt Constr. Co., 6110 Euclid Ave. About $10,000.

O., Cleveland—K. V. Painter, 6523 Euclid Ave., has awarded the contract for an 8 story commercial building on East 30th St. and Euclid Ave. to A. W. Kilbourne Co., 6523 Euclid Ave. Steam heating system will be installed in same. About $1,000,000.

O., Columbus—The Columbus Die, Tool & Machine Co., 955 Cleveland Ave., has awarded the contract for a 36 x 36 ft. boiler house to Chas. Snyder, 2535 Findlay Ave. Estimated cost $8,000.

Ind., Evansville—The Vendome Theater Co. has awarded the contract for a 2 story 145 x 190 ft. theater building on 3rd and Sycamore Sts. to M. J. Hoffman Constr. Co., Furniture Bldg. Steam heating plant will be installed in same. About $500,000.

Ind., Evansville—The Standard Realty Co. has awarded the contract for a 3 story, 110 x 180 ft. theater and hotel on 6th and Main Sts., to M. J. Hoffman Constr. Co., Furniture Bldg., $692,000. Steam heating plant will be installed in same. Noted August 10.

Ind., Indianapolis—The Methodist Hospital has awarded the contract for a 6 story, 80 x 170 ft. hospital addition on 16th St. to J. G. Karstedt Constr. Co., Lemcke Bldg. A vapor steam heating system will be installed. About $300,000.

Minn., Minneapolis—The Bd. Educ. has awarded the general contract for a 2 story, 8 room building of the Eugene Field School to F. N. Hegg, 2942 Nicollet Ave., at $76,995 and for heating, plumbing and ventilating to the Western Heating Co., 13 East 36th St., at $21,453.

N. M., Fort Stanton—J. A. Wetmore, Supervising Archt., Treasury Dept., Wash., D. C., has awarded the contract for the installation of a boiler and new system of piping, here, to Chris Irving, 1525 Larimer St., Denver, Col., at $12,584. Noted August 3.

Ont., London—The Benson Hines Hotel Co. has awarded the contract for an 11 story hotel including steam heating system on Richmond St. to George A. Fuller Co., 45 St. Alexander St. About $1,500,000.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

POWER-PLANT SUPPLIES

HOSE—

	Fire
Underwriters' 2½-in.	50-Ft. Lengths
Common, 2½-in.	85c. per ft.
	30%

	Air		
	First Grade	Second Grade	Third Grade
¼-in. per ft.	$0.60	$0.40	$0.30

Steam—Discounts from List

First grade..... 20% Second grade.....30% Third grade....45%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition..... 50% Best grade..... 20%
Standard..... 30–10%

LEATHER BELTING—Present discounts from list in fair quantities (½ doz. rolls):

Light Grade	Medium Grade	Heavy Grade
30%	25%	20%

RAWHIDE LACING { For cut, best grade, 25%, 2nd grade, 30%. For laces in sides, best, 79c per sq. ft.; 2nd, 75c. Semi-tanned: cut, 20%; sides, 83c per sq. ft.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam	$1.00
Asbestos for high-pressure steam	1.70
Duck and rubber for piston packing	1.00
Flax, regular	1.20
Flax, waterproofed	1.70
Compressed asbestos sheet	.90
Wire insertion asbestos sheet	1.50
Rubber sheet	.50
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.30
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.30
Asbestos wick, ½- and 1-lb. balls	.85

PIPE AND BOILER COVERING—Below are part of standard lists, with discounts.

PIPE COVERING		BLOCKS AND SHEETS	
Pipe Size	Standard List Per Lin.Ft.	Thickness	Price per Sq.Ft.
1-in.	$0.27	½-in.	$0.27
2-in.	.36	1 -in.	.30
6-in.	.80	1½-in.	.45
4-in.	.60	2 -in.	.60
3-in.	.45	2½-in.	.75
8-in.	1.10	3 -in.	.90
10-in.	1.30	3½-in.	1.05

85% magnesia high pressure..... List +5%

For low-pressure heating and return lines { 4-ply..... 50% off; 3-ply..... 52% off; 2-ply..... 54% off

GREASES—Prices are as follows in the following cities in cents per pound for barrel lots:

	Cincinnati	Chicago	St. Louis	Birmingham	Denver
Cup	8½	6.6	8@ 9	8½	13½
Fiber or sponge	8½	8.6	12@15	8½	20
Transmission	10	8.1	12@15	8½	20
Axle	...	4.8	6@ 6½	5½	7½
Gear	6½	6.1	8@9	5½	8½
Car journal	12(gal.)	4.7	23@25	8½	8½

COTTON WASTE—The following prices are in cents per pound:

	New York		Cleveland	Chicago
	Current	One Year Ago		
White	15.00@17.00	13.00	16.00	11.00 to 14.00
Colored mixed	9.00@14.00	9.00 to 12.00	12.00	9.50 to 12.00

WIPING CLOTHS—Jobbers' price per 1000 is as follows:

	13½ x 13½	13½ x 20½
Cleveland	$55.00	$65.00
Chicago	41.00	43.50

LINSEED OIL—These prices are per gallon:

	New York		Chicago	
	Current	One Year Ago	Current	One Year Ago
Raw in barrels (5 bbl. lots)	$1.25	$2.25	$1.67	$2.10
5-gal. cans	1.40	2.40	1.92	2.30

WHITE AND RED LEAD—Base price per pound:

	Red				White	
	Current		1 Year Ago		Current	1 Yr. Ago
	Dry	In Oil	Dry	In Oil	Dry and In Oil	Dry and In Oil
100-lb. keg	13.50	17.00	13.00	14.50	15.50	13.00
25- and 50-lb. kegs	15.75	17.25	13.25	14.75	15.75	13.25
12½-lb. keg	16.00	17.50	13.50	15.00	16.00	13.50
1-lb. cans	18.50	20.00	15.00	16.50	15.00	15.00
5-lb. cans	20.50	22.00	16.00	17.50	16.00	16.00

500 lb. lots less 10% discount; 2000 lb. lots less 10–2½%.

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ⅜ and smaller	List net	40%	30%
Tinned	List net	40%	30%

Boiler rivets, ½, ⅝, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.:

New York.....$6.00 Chicago.....$5.62 Pittsburgh.....$4.50

Structual rivets, same sizes:

New York.....$7.10 Chicago.....$5.72 Pittsburgh.....$4.60

REFRACTORIES—Following prices are f. o. b. works,

Bauxite brick, 56% alumina, f.o.b. Pittsburgh	M.	$160
Chrome brick, f.o.b. Chester, Pa., carlots	net ton	100– 110
Chrome brick, 9 in. strs. and sizes, f.o.b. Baltimore	net ton	90– 95
Fi.e clay brick, 1st quality, 9 in. shapes, f.o.b. Pennsylvania, Ohio and Kentucky works	M.	55– 60
Fire clay brick, 1st quality, f.o.b. St. Louis	M.	45– ...
Fire clay brick, 1st quality, f.o.b. New Jersey	M.	75– ...
Fire clay brick, 2d quality, 9 in. shapes, f.o.b. Pennsylvania, Ohio and Kentucky works	M.	50– 55
Magnesite brick, 9 in. straights, f.o.b. Baltimore	net ton	110– 120
Magnesite brick, 9 in. sizes and shapes larger than 9 in.		Regular extras
Magnesite brick, f.o.b. Chester	net ton	110– 120
Silica brick, 9 in. and 9 in. sizes, f.o.b. works, Chicago district	M.	65– ...
Silica brick, f.o.b. Birmingham	M.	56– 61
Silica brick, f.o.b. Mt. Union, Pa	M.	55– 60

BABBITT METAL—Warehouse prices in cents per pound:

	New York		Cleveland		Chicago	
	Current	One Year Ago	Current	One Year Ago	Current	One Year Ago
Best grade	90.00	87.00	60.50	79.00	60.00	75.00
Commercial	50.00	42.00	21.00	17.50	15.00	15.00

SWEDISH (NORWAY) IRON—The average price per 100 lb., in ton lots, is:

	Current	One Year Ago
New York	$20.00	25.50–30.00
Cleveland	20.00	20.00
Chicago	21.00	16.50

In coils an advance of 50c. usually is charged.
Domestic iron (Swedish analysis) is selling at 12c. per lb.

SHEETS—Quotations are in cents per pound in various cities from warehoues also the base quotations from mill:

Blue Annealed	Large Mill Lots Pittsburgh	St. Louis	Chicago	San Francisco	New York Current	New York One Yr. Ago
No. 10	$3.55@$7.50	$7.09	$7.02	$8.65	$7.12@$8.00	$4.57
No. 12	3.60@ 7.55	7.09	7.07	8.70	7.27@ 8.05	4.62
No. 14	3.65@ 7.60	7.09	7.12	8.75	7.22@ 8.10	4.67
No. 16	3.75@ 7.70	7.09	7.17	8.85	7.32@ 8.20	4.77
Black						
*Nos. 18 and 20	4.15@ 8.30	8.10	7.80	10.60	8.30@ 9.80	5.30
*Nos. 22 and 24	4.20@ 8.35	8.10	7.85	10.65	8.35@ 9.85	5.35
*No. 26	4.25@ 8.40	8.10	7.90	10.70	8.40@ 9.90	5.40
*No. 28	4.35@ 8.50	8.10	8.00	10.80	8.50@10.00	5.50
Galvanized						
No. 10	4.70@ 8.50	9.60	8.50	.....	8.80@11.50	6.20
No. 12	4.80@ 8.60	9.60	8.60	11.35	8.90@11.50	6.25
No. 14	4.80@ 8.60	9.60	8.60	11.35	8.90@11.50	6.30
Nos. 18 and 20	5.10@ 8.90	9.60	8.90	11.65	9.15@11.90	6.60
Nos. 22 and 24	5.25@ 9.05	9.60	9.05	11.80	9.30@12.05	6.75
*No. 26	5.40@ 9.20	9.60	9.20	11.95	9.45@12.20	6.90
†No. 28	5.70@ 9.50	9.60	9.50	12.25	9.75@12.50	7.20

*For painted corrugated sheets add 30c. per 1000 lb. for 5 to 28 gage; 25c. for 19 to 24 gages; for galvanized corrugated sheets add 15c., all gages.

WROUGHT PIPE—The following discounts are to jobbers for carload lots on the Pittsburgh basing card:

BUTT WELD

Steel			Iron		
Inches	Black	Galv.	Inches	Black	Galv.
⅛ to 3	45 to 57½	41½ to 44	⅛	15½ to 25½	+1½ to 11
			¼	19½ to 29½	1½ to 11½
			⅜ to 1½	24½ to 34½	8 to 18½

LAP WELD

2	47 to 50½	34½ to 38	2	20½ to 28½	6½ to 14½
2½ to 6	50 to 53½	37½ to 41	2½ to 6	22½ to 30½	9½ to 17½
7 to 12	47 to 50½	33½ to 37	7 to 12	19½ to 27½	6½ to 14½
13 and 14	37½ to 41				
15	35 to 38½				

BUTT WELD, EXTRA STRONG, PLAIN ENDS

⅛ to 1½	52 to 55½	39½ to 43	⅛ to 1½	24½ to 34½	9½ to 19½
2 to 3	53 to 56½	40½ to 44			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	45 to 48½	33½ to 37	2	21½ to 29½	8½ to 16½
2½ to 4	48 to 51½	36½ to 40	2½ to 4	23½ to 31½	11½ to 19½
4½ to 6	47 to 50½	35½ to 39	4½ to 6	22½ to 30½	10½ to 18
7 to 8	43 to 46½	29½ to 33	7 to 8	14½ to 22½	2½ to 10½
9 to 12	38 to 41½	24½ to 28	9 to 12	9½ to 17½	5½ to+2½

BOILER TUBES—The following are the prices for carload lots, f.o.b. Pittsburgh:

Lap Welded Steel		Charcoal Iron	
3½ to 4½ in.	15 to 40½	1¾ and 1¾ in.	+20
2½ to 3¼ in.	10 to 30½	2 and 2¼ in.	+10
2¼ in.	4 to 24	2½ and 2¾ in.	+1
1¼ to 2 in.	+½ to—19½	3 and 3½ in.	−1½
		3½, 4 and 4½ in.	−8

Standard Commercial Seamless — Cold Drawn or Hot Rolled

	Per Net Ton		Per Net Ton
1 in.	$327	1¼ in.	$207
1¼ in.	267	2 to 2½ in.	177
2½ in.	257	2¾ to 3¼ in.	167
1½ in.	207	4 in.	187
		4½ to 5 in.	207

ELECTRICAL SUPPLIES

ARMORED CABLE—

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$104.00(net)	$138.00	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:

Less than coil lots	+ 5%
Coils to 1,000 ft.	− 5%
1,000 ft. and over	−10%

List	Net
	+15%
	7%

BATTERIES, DRY—Regular No. 6 size red seal, Columbia, or Ever-Ready:

	Each, Net
Less than 12	$0.45
12 to 50	.38
50 to 125 (bbl.)	.35
125 (bbl.) or over	.32

CONDUIT, ELBOWS AND COUPLINGS—These prices are in 100-lb. lots, f. o. b. New York, with 10-day discount of 5 per cent.

Size, In.	Conduit Black 2,500 to 5,000 Lbs.	Conduit Galvanized 2,500 to 5,000 Lbs.	Elbows Black 2,500 to 5,000 Lbs.	Elbows Galvanized 2,500 to 5,000 Lbs.	Couplings Black 2,500 to 5,000 Lbs.	Couplings Galvanized 2,500 to 5,000 Lbs.
¼	85.00	93.50	22.00	524.60	6.65	7.30
⅜	11.50	126.50	29.00	32.00	11.25	12.37
½	170.00	187.00	41.00	45.00	15.50	17.00
¾	230.00	253.00	52.00	57.00	20.70	23.60
1	275.00	302.50	70.05	78.00	25.00	27.50
1¼	375.00	403.00	130.00	145.09	33.70	37.00
1½	585.00	613.80	210.00	235.00	47.50	53.00
2	765.00	841.50	560.00	620.00	70.00	78.00
2½	920.00	1,012.00	1,350.00	1,485.00	92.00	114.00
3	1,170.00	1,287.00	1,469.00	1,617.00	115.00	140.00

Standard lengths rigid, 10 ft. Standard lengths flexible, ½ in., 100 ft. Standard lengths flexible, ¾ to 2 in., 50 ft.

CONDUIT NON-METALLIC, LOOM—

Size I. D., In.	Feet per Coil	List, Ft.	
¼	250	$0.05½	
⅜	250	.06	
½	250	.09	
¾	200	.12	
1	200	.15	Coils..... 40% off
1¼	150	.18	Less coils, 25% off
1	100	.25	
1½	100	.33	
1½	Odd lengths	.40	
2	Odd lengths	.55	

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.12	D. P. D. B.	$0.43
D. P. M. L.	.21	T. P. to D. P. S. B.	.26
T. P. M. L.	.33	T. P. S. B.	.38
D. P. S. B.	.23	T. P. D. B.	.64

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.50	$1.30	$1.68
T. P. M. L.	.70	1.70	2.40
D. P. S. B.	.63	1.60	.....
T. P. S. B.	1.15	2.40	.....
D. P. D. B.	1.10	3.00	.....
T. P. D. B.	1.90	5.40	.....
T. P. to D. P. D. B.	1.30	3.80	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton twisted	$23.00
No. 16 cotton twisted	27.50
No. 18 cotton parallel	26.50
No. 16 cotton parallel	34.50
No. 18 cotton reinforced heavy	38.00
No. 16 cotton reinforced heavy	45.00
No. 18 cotton reinforced light	33.50
No. 16 cotton reinforced light	39.50
No. 18 cotton Canvasite cord	30.00
No. 16 cotton Canvasite cord	33.50

FUSES, ENCLOSED—

250-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.25
35-amp. to 60-amp.	100	.35
65-amp. to 100-amp.	50	.90
110-amp. to 200-amp.	25	2.00
225-amp. to 400-amp.	25	3.60
425-amp. to 600-amp.	10	5.50

600-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.40
35-amp. to 60-amp.	100	.60
65-amp. to 100-amp.	50	1.50
110-amp. to 200-amp.	25	2.50
225-amp. to 400-amp.	25	5.50
450-amp. to 600-amp.	10	8.00

Discount:	
Less 1-5th standard package	15%
1-5th to standard package	28%
Standard package	45%

FUSE PLUGS, MICA CAP—

0–30 ampere, standard package	$5.25C
0–30 ampere, less than standard package	6.00C

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs Mazda B— Watts	Plain	Frosted	No. in Package	Pear-Shaped Bulbs Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.40	$0.45	100	75	$0.75	$0.80	50
15	.40	.45	100	100	1.10	1.25	24
25	.40	.45	100	150	1.55	1.70	24
40	.40	.45	100	200	2.10	2.30	24
50	.40	.45	100	300	3.15	3.40	24
60	.45	.50	100				12
				500	4.60	4.90	12
				750	6.50	6.90	8
				1,000	7.50	7.95	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.24
Composition 2-piece attachment plug	.32
Swivel attachment plug	.20
Current taps	.40

RUBBER-COVERED COPPER WIRE—Per 1000 ft. in New York.

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$12.50	$15.50	$17.00	$28.50
12	14.96	18.50	21.45	35.00
10	20.62	24.75	28.05	46.00
8	28.90	33.30	38.50	66.00
6	.....	.....	58.75	.....
4	.....	.....	80.75	.....
2	.....	.....	111.00	.....
1	.....	.....	154.00	.....
0	.....	.....	181.50	.....
00	.....	.....	220.00	.....
000	.....	.....	265.00	.....
0000	.....	.....	330.00	.....

Prices per 1000 ft. for Rubber-Covered Wire in Following Cities:

	Denver Single Braid	Denver Double Braid	Denver Duplex	Birmingham Single Braid	Birmingham Double Braid	Birmingham Duplex	St. Louis Single Braid	St. Louis Double Braid	St. Louis Duplex
14	$15.64	.....	$38.45	$12.23	.....	$38.64	$15.64	.....	$38.45
10	24.50	.....	.....	27.60	.....	65.57	24.50	.....	58.70
8	33.48	$56.81	.....	38.64	.....	87.33	33.48	.....	.....
6	.....	77.17	.....	69.12	.....	.....	.....	56.81	.....
4	.....	108.10	.....	.....	$107.42	.....	.....	77.17	.....
2	.....	142.00	.....	.....	138.46	.....	.....	108.10	.....
1	.....	167.70	.....	.....	178.52	.....	.....	142.00	.....
0	.....	198.20	.....	.....	217.09	.....	.....	167.70	.....
00	.....	234.60	.....	.....	263.57	.....	.....	198.20	.....
000	.....	279.60	.....	.....	320.44	.....	.....	234.60	.....
0000	.....	.....	.....	.....	389.17	.....	.....	279.60	.....

Pittsburg—23c. base; discount 50%. St. Louis—30c. base.

SOCKETS, BRASS SHELL—

½ In. or Pendant Cap Key Each	Keyless Each	Pull Each	¾ In. Cap Key Each	Keyless Each	Pull Each
$0.33	$0.30	$0.60	$0.39	$0.36	$0.66

Less 1-5th standard package	+50%
1-5th to standard package	+20%
Standard package	−10%

WIRE, ANNUNCIATOR AND DAMPPROOF OFFICE—

No. 18 B. & S. regular spools (approx. 8 lb.)	55c. lb
No. 18 B. & S. regular 1-lb. coils	56c. lb

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 60c. lb., 100 lb. lots	55c. lb
Rubber tape, ¾ in., less 100 lb. 65c. lb., 100 lb. lots	60c. lb
Wire solder, less 100 lb. 47c. lb., 100 lb. lots	42c. lb
Soldering paste, 2 oz. cans	$1.20 doz

SWITCHES, KNIFE—

TYPE "C" NOT FUSIBLE

Size, Amp.	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$0.42	$0.68	$1.02	$1.36
60	.74	1.22	1.84	2.44
100	1.50	2.50	3.76	5.00
200	2.70	4.50	6.76	9.00

TYPE "C" FUSIBLE, TOP OR BOTTOM

30	.70	1.06	1.60	2.12
60	1.18	1.80	2.70	3.60
100	2.38	3.66	5.50	7.30
200	4.40	6.76	10.14	13.50

Discounts:	
Less than $10.00 list value	+25%
$10 to $25 list value	+10%
$25 to $50 list value	+5%
$50 to $200 list value	−10%
$200 list value or over	−15%